THE EFFICIENCY INDEX

Which education systems deliver the best value for money?

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With introductions by **Lord Andrew Adonis** and **Andreas Schleicher**

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LEARNING FOR TOMORROW

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GEMS EDUCATION SOLUTIONS
LEARNING FOR TOMORROW

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Preface

by Chris Kirk

Chief Executive, GEMS Education Solutions

Everyone agrees on the importance of education, and that each child and student deserves the best education they can get. We all want to improve standards: but people continue to disagree fundamentally about the ways in which this can be done. It has also been observed that education seems to be uniquely isolated from the huge changes that have swept through almost every other sector, including apparently similar ones such as Health.

Since our establishment in 2011, GEMS Education Solutions has sought to examine how education systems can be transformed and what roles the public and private sector can play in this transformation. Our philosophy for tackling the world's toughest education challenges is a practical one: to find out what can be learned, what can adopted, and how this knowledge can benefit learners to find success and become more globally competitive.

Our research publications focus on three main questions: Can the outcomes of education and skills systems be improved? Can education system processes and school/college practices be improved? And can education and skills funding be increased to make more resources available?

In *Creating the 21st Century Workforce*, we gathered opinions from some of the world's most influential political, business and education leaders, asking them how today's education and skills systems are performing and how they can be improved to meet tomorrow's needs. In our second publication, *A Powerful Impact: The Importance of Engaging Parents*, a group of leading experts in parent, family and community engagement gave their insights on how to adopt best-practice parent engagement initiatives. Our report entitled *Social Impact Bonds and Education in Latin America* examined new mechanisms for investing in global education; we wanted to explore fresh ways to invest in public education while giving the taxpayer value for money and addressing age-old social problems.

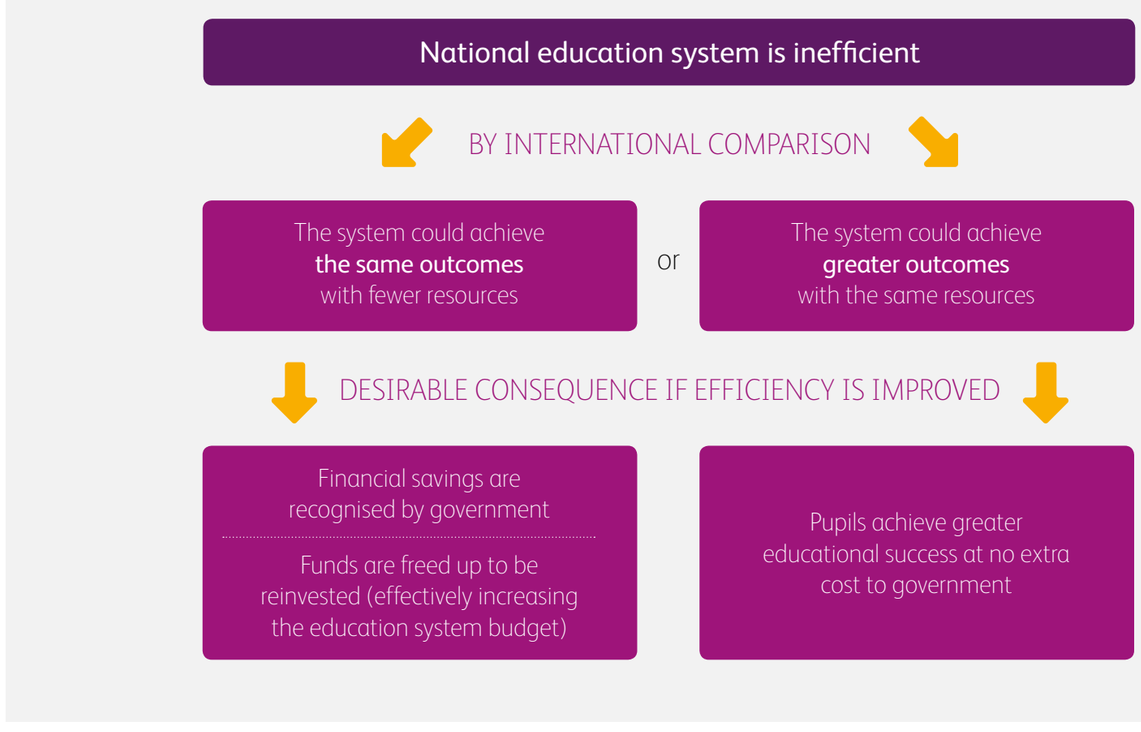
Our Efficiency Index opens up the question of resource allocation as a key policy decision within an education system's processes. If an education system is inefficient, then some of the funding it consumes could be better used to further improve outcomes for learners; or some money could be released from the education system to be spent elsewhere, without any detriment to learners.

Efficiency is a relative question and so we can only understand it by comparing one system with another, internationally. Furthermore, changes made in a system today may not affect measurable learner outcomes for some years, so we need to explore efficiency over time. Fortunately, a research team comprising Professor Peter Dolton and Dr Oscar Marcenaro-Gutiérrez had previously looked at OECD data relating to educational expenditure and educational outcomes and believed that a method could be constructed to achieve this. Primary econometric analysis and evaluation was conducted by this team, with a further analytical narrative and policy perspective created by Adam Still, an Education Finance and Development specialist within GEMS Education Solutions. Natasha Turner, our senior Marketing and Communications Manager, oversaw the production of this publication.

We are incredibly grateful for the input of our Advisory Board made up of Lord Andrew Adonis, Andreas Schleicher and Russell Hobby. The final report has been much influenced by their expertise, insights and recommendations.

The report as a whole seeks to provide a lens through which to debate what we value about education, and how we can improve the allocation of resources in a system to increase value for money. In our country-level analysis we also aim to raise questions about what individual countries might do to improve standards; but we fully acknowledge that in so doing we are starting a debate, rather than concluding it.

Figure 1. Why Efficiency Matters



Topic Insight

The Policy Perspective

by Lord Andrew Adonis

Lord Andrew Adonis was Minister for Education in the UK Government of Tony Blair (2005-2008).

This GEMS Education System Efficiency Index is invaluable, but not necessarily for straightforward reasons. The merit of looking at questions of efficiency, I believe, is not simply to find out which systems are more efficient than others: rather, it is to use efficiency as a lens through which to examine how excellent results can be achieved in different environments, and using varying methods.

The most striking finding of the Index is that the two most efficient systems (Finland and Korea) score highly because they combine very high standardised PISA scores with only moderately high teacher salaries and relatively high pupil/teacher ratios. Their 'output' – in pupil attainment – is exceptionally high relative to their main 'input' cost, which is what makes them so 'efficient'. Significantly, they are not scoring highly in efficiency terms by combining cheap 'inputs' with only moderate 'outputs.'

Finland's teacher salaries, while above the international average, are notably much lower than those in richer European nations, such as Germany, Switzerland, Belgium, and the Netherlands. In Finland, teaching is a highly attractive career but without exceptional salary levels. Salaries are somewhat higher in Korea than in Finland, but still well below the aforementioned European countries.

The countries ranked third and fourth in the overall index (Czech Republic and Hungary) have exceptionally low teacher salaries, in common with most of the former Eastern European states. This makes them less interesting to policymakers looking for models of excellence and reform.

No school can be better than its teachers, and Finland and Korea have exemplary teaching workforces, with intense competition for teacher training places. In these countries, however, it is clearly not high salaries that draw exceptionally able graduates into teaching. There are also important cultural forces at work which boost teacher status, as explained in Pasi Sahlberg's *Finnish Lessons: what the world can learn from educational change in Finland*.

These forces are partly historical, but are also related to investment in teachers. For example, all Finnish teachers have master's degrees, while Korea also has exemplary teacher training and support. I vividly recall visiting a primary school in Helsinki and asking the principal what the biggest problem she had with her teachers was. "So many of the good ones want to go and do doctorates," she replied, to my astonishment: as Minister for Schools in England, no one had ever raised *this* issue with me as a problem in teacher retention!

Finland and Korea, then, are notably successful. However, bracketing them together as exceptionally 'efficient' only serves to raise another significant lesson from this Index: namely, that there are great differences between the two systems in aspects not included in this assessment.

To illustrate: Finland is widely regarded as a model for a self-regulating 'comprehensive' education system, with teachers in charge and little intervention by way of national testing until the very end of compulsory education. Parents are not encouraged to overly 'push' their children, and certainly not to the detriment of their wider social development. There is also considerable emphasis on the arts and creativity as part of a broad and balanced education.

Korea, by contrast, is widely regarded as a model for the ultra-disciplined Asian education system, with constant testing and examination, long hours of semi-compulsory study beyond the school day, and a strong bias towards mathematics and the sciences. Creativity and wider cultural education are less emphasised – though national policy is now seeking to enhance their status. Again, it is an image from a ministerial visit which sticks in my mind: the long queues of pupils at bus stops in Seoul on their way home after evening (private) school, and the posters advertising celebrity lecturers at these schools. It was the same in Taipei.

It is clear, then, that high-achieving education systems come in more than one form: and broadly equivalent 'inputs' and 'outputs' in terms of spending levels and pupil attainment can generate very different methods and cultures of learning.

It is therefore important not to take simple lessons from this GEMS index. There is no easy recipe for a 'good efficient' system. But a highly professional teaching force, which is well but not excessively paid, and with pupil/teacher ratios not excessively small, is a good starting point.

Topic Insight

The Challenge to Innovate

by Andreas Schleicher

Andreas Schleicher is Director for Education and Skills, and Special Advisor on Education Policy to the Secretary-General at the Organisation for Economic Co-operation and Development (OECD) in Paris.

Education transforms lives and drives economies. Without the right education, people languish on the margins of society; technological progress does not translate into economic growth; and countries cannot compete in an increasingly knowledge-based global society. If there is one lesson the global economy has taught us over the last few years, it is that we cannot artificially bail ourselves out of a crisis simply using quantitative easing and related methods. The best course for countries to drive their economies forward remains to educate more people in ways that lead to better jobs and better lives.

There are some inconvenient truths about education: spending explains less than a fifth of the performance differences among countries, i.e. two countries with similar spending can produce very different educational results. The world is also no longer neatly divided into rich, well-educated countries and poor, badly educated countries. Most worryingly, education in most countries has not improved as it became more expensive: while spending per pupil in the industrialised world increased by more than 30 % over the last decade, learning outcomes in most countries have remained flat.

To illustrate the present situation in teaching, imagine a teacher and a surgeon from the 1940s travelling in time to the year 2014. The surgeon, who in the 40s was able to operate with a small set of instruments and their existing academic knowledge, would now find a world in which surgeons are part of a dynamic profession that owns and builds its rapidly advancing professional practice, working as part of complex multi-disciplinary teams in a highly technological workplace. In contrast, however, most teachers from the 1940s would find their workplace and the work organisation of schooling largely unchanged today.

There are plenty of reasons for this lack of development in education. One reason is that the most effective spending choices are often not the most politically convenient. For example, research has shown consistently that high-performing education systems tend to prioritise the quality of teachers over the size of classes. And yet, much of the additional money the industrialised world has spent on education over the last decade has gone into smaller classes.

This report takes a refreshing look at internationally comparative data to examine the spending choices made by those countries that are achieving the best results with the least resources. Of course, such analyses are never perfect. The pupil learning results that this report uses as benchmarks for success are important, but they are not the only outcomes educators strive for. The relationship between the volume of inputs and their quality also remains uncertain. Similarly, the apparent high degree of efficiency of the East Asian education systems may, at least in part, be due to significant household spending on out-of-school education that is not accounted for by the analysis. Finally, the performance differences among the countries examined here cover less than a quarter of the variability in outcomes that are observed between schools and pupils.

These caveats should not diminish the importance of this report, which breaks the silence on the efficiency of educational services. It raises questions about what is possible in improving value for money, at a time at which many countries struggle with tight public budgets. It also sends an important message to poorer countries that significant educational improvement is possible even with limited investment in education. Those who consider educational services too important to be measured against their efficiency will deprive many children of a better education and a better life. Those who consider it unfair or inappropriate to compare the efficiency of educational services across national and cultural boundaries ignore the fact that, in a global economy, the benchmark for educational success is no longer improvement by national standards alone, but the best-performing school systems internationally.

The world has become indifferent to tradition and past reputations, unforgiving of frailty and ignorant of custom. Success will go to those educators, institutions and countries which are swift to adapt, slow to complain and open to change. The task for governments is to help their citizens rise to this challenge.

Executive Summary

by Adam Still
Education Finance and Development Specialist, GEMS Education Solutions

In TIMSS, PIRLS and PISA we now have global comparators for the educational outcomes produced by participating countries. Coupled with the fact that national education budgets represent a significant proportion of government spending[1], the most pressing question is one of efficiency: whose systems are producing the best results per dollar? At a time when education systems are under pressure to modernise and produce young people with skills for the 21st century, the global economy is also under pressure to provide resources – efficiency has never been more relevant. The GEMS Education Solutions Efficiency Index is the first comprehensive international analysis of education system inputs and their relative impact on educational outcomes. It looks at how efficiently significant cost-drivers are allocated in each country, and ranks 30 OECD countries based on these inputs and the pupil outcomes achieved.

Education efficiency is not immediately concerned with raising PISA scores. To give an analogy: the fuel efficiency of a car is important because it tells you how many miles you can travel per gallon of fuel. But if you plan to embark on a long journey and want to know how to travel further, the answer is still to put more fuel in the tank, regardless of your car's efficiency. The same is true of education systems. With unlimited funding available much more could be done to increase education outcomes, but this is unrealistic: government budgets are limited, and spending needs to be prioritised accordingly in order to deliver value for money.

Our methodology shows that teacher salaries and class size are the only two contributing factors, out of 63 different components studied, that have a demonstrable impact on education outcomes, as defined by PISA scores. Improving either or both of these has significant cost implications, requiring additional resources. However, we find that there is a point beyond which increased investment does not guarantee an increased return, thereby introducing inefficiency.

The message is that education system inefficiency can be a result of both underpaying and overpaying teachers. To illustrate: if teachers are underpaid, it may be harder to recruit high-calibre individuals into the profession, or retain them. Learning outcomes will suffer - which impacts efficiency. Conversely, if teachers are overpaid, they may have fewer incentives to perform well once in secure positions; or, in some cases, higher salaries may be given to those teachers whom achieve excellence regardless of their current level of compensation. In such cases, increased spending on teachers' salaries may not achieve the hoped-for improvements in performance, and again efficiency suffers. Similarly, our research also suggests that from an efficiency perspective, class sizes can be both too big and too small.

Our calculations find that Finland strikes the most efficient balance between teacher salaries and class sizes in order to produce educational outcomes. Using this as our benchmark for "maximum" efficiency we are able to calculate how PISA scores can be theoretically raised to Finland's level by adjusting these two inputs – both of which are within the power of policymakers. This optimisation does not entail a one-size-fits-all approach: countries can use a different combination of teacher salary level and class size to improve their educational outcomes.

The report acknowledges that efficiency may not be the most important factor for some countries. Some countries will choose to pursue policies in which improving educational quality, rather than education system efficiency, is their most important goal. To return to the car analogy: customers buying luxury sports cars are not likely to be concerned with fuel efficiency; they can choose to prioritise other desirable features and are prepared to pay higher fuel costs for the privilege. This is an informed choice: but who are the high-end customers in education? Are they aware of the premium they are paying? If so, the additional benefits should be clearly defined for the taxpayer. If not, improving system efficiency should be of great interest.

Regardless of context, the Efficiency Index sheds light on the effectiveness of the spending choices that policymakers are currently making. As governments seek to improve their education systems within financial constraints, we hope to inform debate about which items of educational expenditure are likely to make the greatest impact on the attainment of children.

1 An average of 5.4% of GDP for OECD countries. 73% of countries lie within +/-1% of this figure.

The Efficiency Index

Each year, trillions of dollars are spent by governments on their education systems ($2.2 trillion total for the 30 countries in our study)[2] with the objective of educating their children to the highest standard possible. Some governments use available budgets more efficiently than others.

Using econometric methods we examine 30 OECD countries to ascertain which inputs funded by governments really do make a difference, and which countries are combining these inputs most effectively to produce the best educational outcomes for each dollar invested. The results are based on internationally comparable data collected over the last 15 years, using standardized PISA scores as the measurement of system output.

In summary we find:

Finland, **Korea** and the **Czech Republic** are the most educationally efficient countries

In general, **Mediterranean** countries exhibit quite low efficiency (**Greece**, **Spain**, **Portugal** and **Italy**)

Switzerland and **Germany**, whose GDP per head is over 50 % higher than the **Czech Republic**, pay much higher teacher salaries but attain a much lower efficiency score ranking

2 Authors' calculations.
3 Authors' calculations.

Table 1. Efficiency scores (%) by country[3]

Ranking	Country	Efficiency Scores	PISA rank (2012 Maths)
1	Finland	87.81 %	5
2	Korea	86.66 %	1
3	Czech Republic	84.38 %	14
4	Hungary	84.08 %	24
5	Japan	83.88 %	2
6	New Zealand	83.30 %	12
7	Slovenia	83.28 %	10
8	Australia	81.23 %	9
9	Sweden	80.58 %	23
10	Iceland	79.39 %	17
11	UK	78.71 %	16
12	France	78.69 %	15
13	Israel	77.84 %	25
14	Netherlands	76.80 %	4
15	Ireland	76.80 %	11
16	Austria	74.68 %	8
17	Norway	74.05 %	18
18	Belgium	73.52 %	6
19	USA	72.66 %	22
20	Chile	72.54 %	28
21	Turkey	71.44 %	27
22	Denmark	70.60 %	13
23	Italy	69.81 %	20
24	Portugal	68.29 %	19
25	Germany	67.01 %	7
26	Spain	63.09 %	21
27	Greece	60.64 %	26
28	Switzerland	59.71 %	3
29	Indonesia	51.13 %	30
30	Brazil	25.45 %	29

Introducing Efficiency

- **Education systems are huge:** they consume vast and increasing quantities of national resource, for which there is competition from other sectors.
- **Efficient returns should be expected from this investment:** in this report we study whose system is generating the greatest educational return for each dollar invested.

There are around 1.3 billion children enrolled in primary and secondary schools worldwide[4]. Education is an enormous global operation where cultures and strategies are remarkably different. In this research we seek the answer to the following question: Given the limited resources available, which governments are using these most effectively to produce the best outcomes for their young people, as measured by their educational attainment? In the process we examine which education resources (or system inputs) produce the most valuable return on investment – a potentially powerful insight for policymakers wishing to increase efficiency and drive their system forward.

This Index is particularly relevant in the context of economic recession. In most countries, public expenditure on school education represents a significant share of total government budget. Furthermore, the global proportion of government spend on education has, on average, risen for the past 20 years (see Figure 2). The Education sector may therefore find it increasingly difficult to compete for funding with other public sectors such as Health, Transport and Defence. There is a potential large financial saving to be made if we can better understand the underlying relationship between resource inputs and pupil performance. As the global economy evolves, technology disrupts, and business processes improve, the role of the public sector in producing highly-educated young people who contribute to social development and economic competitiveness has never been more important. Achieving this without increasing spending is a challenge.

In what follows, we have examined system efficiency from a data-driven perspective, using different econometric approaches for a set of OECD countries. The Efficiency Index we present is a relative measure – Finland has been calculated to be operating at the notional maximum, but even that system could achieve more with less. For example, each education system needs to decide how much funding to invest in teaching materials, infrastructure, reducing class sizes or more highly-paid teachers. This research examines the influence of these measurable inputs over the last 15 years and their effect on the desired output, defined to be PISA scores.

Many other studies have examined the relationships and factors that influence pupil performance. The effects of a high-performing teacher or a child's socio-economic background are two well-documented examples[5]. However, these are micro-level factors that are to a large extent beyond the direct control of a country's education ministry. In this study, we concentrate on the macro-level inputs, controlled by policymakers and subject to the inevitable trade-offs at government level owing to finite spending power.

We ask not which countries are at the top of the PISA league table, but rather:

1. Which countries are highest up the league table given their available resources?
2. Which components of an education system (inputs) have the most significant impact on pupil performance and therefore represent the best value for money?
3. Should systems strive for efficiency or quality (or both)?

4 UNESCO Institute for Statistics, Authors' calculation.
5 See, for example: Sanders and Rivers, Cumulative and Residual Effects of Teachers on Future Student Academic Achievement (1996) and OECD, Overcoming Social Background (2009).

Figure 2[6]. % of National GDP spent on Education - World Average

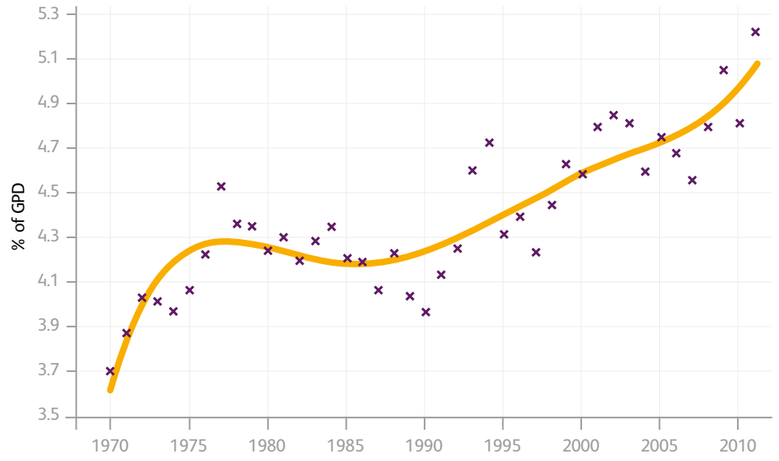
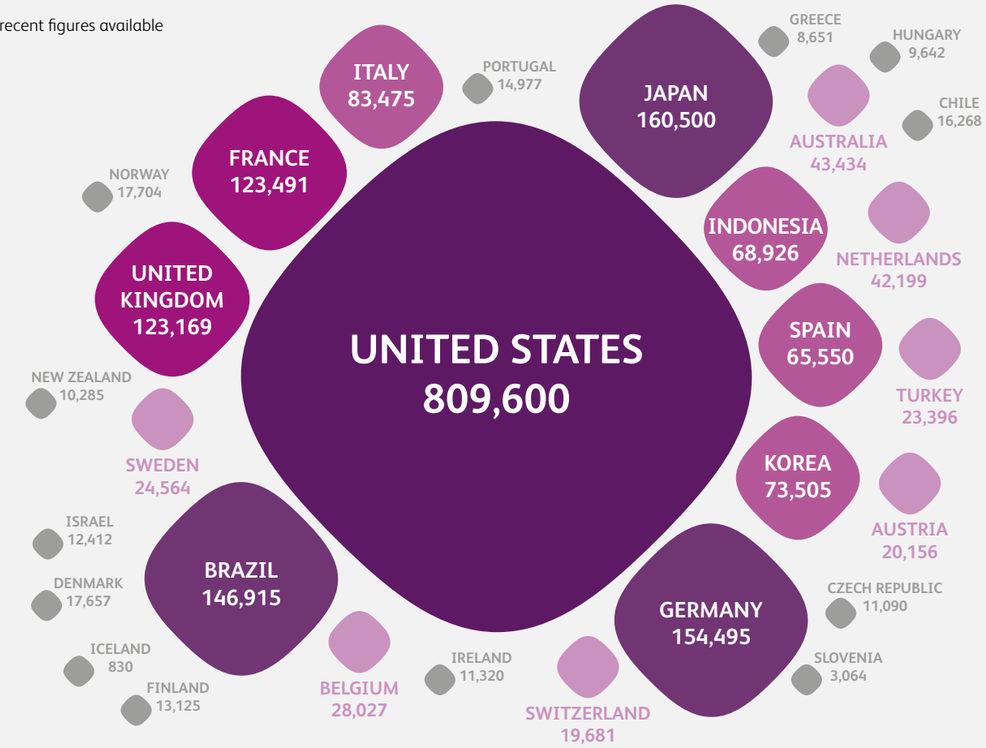


Figure 3[7]. Total education spend ($m)

Most recent figures available



6 Data from UNESCO Institute for Statistics via World Bank DataBank, Authors' calculations.
7 Data from UNESCO Institute for Statistics via World Bank DataBank, Authors' calculations.

More with Less?

- **Only teacher salaries and the pupil/teacher ratio are statistically significant:** of the 63 education system inputs captured by the OECD and TIMSS, our analysis finds that only these two have a material impact on PISA scores.
- **Improving both of these has significant cost implications:** increasing system inputs results in increased outputs, but simply investing more money into the system is not an option available to most countries. Governments must try to be as effective as possible with limited resources.

We are fortunate in now having very detailed comparative performance data across the world which tells us how pupils score on PISA and TIMSS attainment tests.

These league tables have been scrutinised and controversially debated for the last 20 years or so. We also have excellent data from the OECD which facilitate comparison of each country's educational system. We used these to test each input's statistical impact on PISA scores (a total of 63 input variables – see Annex D for a full list). Two of these inputs proved to be statistically significant:

1. Teacher wages
2. Pupil/teacher ratio[8]

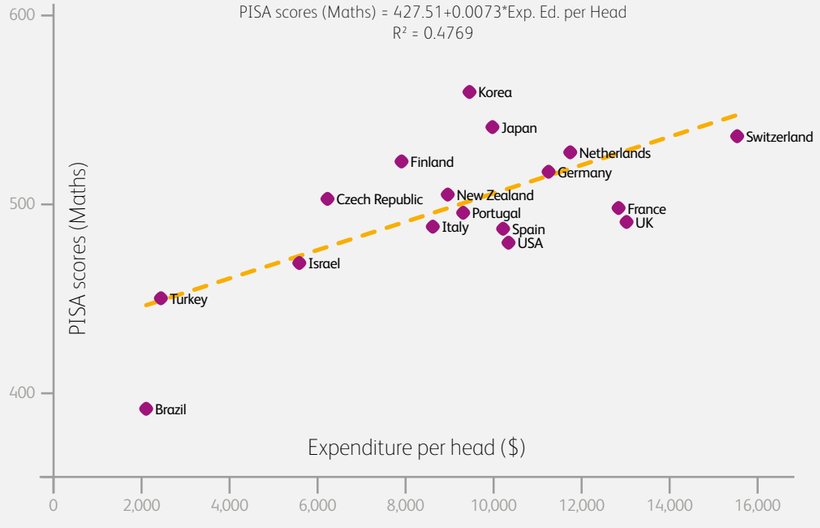
Teacher pay scales have a large and direct impact on government budget, typically accounting for more than 80 % of education budgets[9]. The ratio of pupils per teacher impacts the same budget line (total teacher salaries) by affecting the total number of teachers required by the system for a given number of pupils. Both these variables can (and can only be) altered by the education system policies. They are independent of a child's socio-economic background, demographics, parental involvement, or aspiration level.

Ultimately, the finding above suggests that the more money there is available to spend on teachers, the better results will be – perhaps not a surprising result. We now take the analysis one step further and examine the "optimal" combination of these two inputs within the available funding envelope: rather than require extra resources, could more be achieved with the same (or less)?

Figure 4.
Correlation PISA scores (Maths) – Expenditure per head ($)

Note: We have represented only countries for which we have information also on the status index, tutoring and type of school they attended.

Source: Authors' own calculations.



8 We will use the phrase "class size" interchangeably.
9 UNESCO Institute for Statistics, accessed via http://www.uis.unesco.org/Education/Pages/teachers-statistics.aspx

The Finnish Frontier

- **Over the last 15 years Finland's education system has been the most efficient:** our calculations show that for every dollar spent on teacher salaries and class sizes, Finland's outcomes are greatest.
- **We therefore treat Finland's system** as being the theoretical benchmark of maximum efficiency.

The econometric methodology we have used to construct our efficiency index (stochastic frontier production function analysis[10]) treats the educational system as if it were a company which attempts to obtain an output (pupil attainment via PISA scores) by the transformation of a set of inputs (teacher wages and class size) via the educational process. We condition for other features of each education system: but our findings indicate that these two inputs remain the chief policy lever open to governments aiming to materially improve pupil attainment.

This method calculates and fixes a maximum potential performance ("frontier") which becomes the reference point against which all other countries are measured. Statistically, Finland produces the greatest outcomes for its investment. This isn't to say that the Finnish system is the "right" answer, but rather that the Finnish balance of material inputs creates the most efficient observable system. In fact, this observation is true over the entire period where data is available (see Annex C: "Time Invariance of Efficiency"). A new "frontier" will only become a reality when a system strikes a different balance of inputs that, dollar for dollar, generates higher PISA scores. Given how sensitive education systems can be to cultural and national dynamics, creating one's own efficient combination may be a more realistic ambition than mimicking Finland's.

Consequently, our measure of relative efficiency computes the distance between a country's actual input-output combination and the frontier. Using such a metric, we can express the shortfall of a country's educational system, or inefficiency, from the hypothetical maximum.

Figure 5.
Finland's Rank (out of 30)

Most recent data available.

10 See Annex E.
11 For reference only – does not impact efficiency ranking.

Combinations are Key

- **There is not a single magic ingredient to efficient systems:** efficiency is driven by the appropriate combination of three metrics (2 inputs, 1 output).
- **The two highest ranking countries in the efficiency index (Finland and Korea) have similar characteristics in terms of these metrics:** they achieve good results, pay teachers reasonable wages and have relatively high pupil/ teacher ratios.

Our efficiency scores are based on cross-country pooled data over the last 15 years, using standardized PISA scores as the dependent variable. Although Finland has historically achieved high PISA scores, this is not necessarily a requirement in efficiency stakes. Neither is there a requirement to have very large classes or low teacher salaries (both cost savers), but rather efficiency scores indicate the balance of all these characteristics. Indeed, Table 2 below shows that Finland is not the top performer in any of the determining categories.

Clearly there is a set of countries with high relative educational efficiency. Finland, the Czech Republic and Hungary all score highly, while Korea and Japan also do well. In contrast, Mediterranean countries exhibit, in general, quite low efficiency (Greece, Spain, Portugal and Italy). It is worth noting that the UK is only at around the 30th percentile in our ranking. More striking is the fact that the US, which pays very high average teacher salaries and whose overall education spend is more than 5 times any other country in our study, is two-thirds of the way down the table. Interestingly, wealthy countries like Switzerland and Germany with a GDP per head over 50 % higher than the Czech Republic, with much higher teachers' wages, attain a much lower efficiency score ranking.

The rankings highlight that countries do not necessarily have to pay high teacher wages to efficiently produce outcomes. The Czech Republic and Hungary are two good examples of this; they adopt more "favourable" pupil/teacher ratios instead. The key is in the different combination of inputs.

Interestingly, Finland and Korea are remarkably similarly from a data perspective. They both achieve highly on PISA tests; by international comparison pay teachers moderate wages; and have relatively high pupil/teacher ratios. These two countries top the efficiency ranking despite very different cultural dynamics and approaches to education. This suggests that although efficient systems will exhibit similar macro-level characteristics, there is no right or wrong way to hit some key indicators: the approach has to be appropriate for the environment, although the fundamental combination of inputs is similar.

Table 2.

Most recent available data (N.B. Average data is used in following sections)

	Finland	Hungary	Israel	Portugal	Switzerland
PISA maths score	519 5th	477 24th	466 25th	487 12th	531 3rd
Pupil/teacher ratio	17.06 4th	12.47 15th	11.04 21st	7.16 30th	10.33 22nd
Teacher wages after 15 years ($1,000 PPP corrected)	29.94 15th	10.92 2nd	14.69 3rd	26.25 13th	59.45 30th
Efficiency Index (%) and Rank	87.81% 1st	84.08% 4th	77.84% 13th	68.29% 24th	59.71% 28th

Low PISA scores
Low pupil/teacher ratio
High teacher salaries

High PISA scores
High pupil/teacher ratio
Low teacher salaries

A Point of Policy?

Teachers' Salaries

- **Assuming class sizes can be held constant,** all countries could improve their educational outcomes to Finland's level by either increasing or decreasing teachers' salaries.
- **Inefficiency can be a result of either overpaying teachers** (Switzerland and Belgium top the table) or underpaying teachers (Indonesia and Chile foot the table). These countries occupy 4 of the bottom 6 spots in the overall efficiency rankings.

So far we have described what relationships there might be between underlying measured educational variables of interest in our attempt to understand education efficiency. In this section we turn our attention to potential implications of our analysis. Namely, if we wish to change the efficiency of an educational system, how extreme would those changes have to be? We first consider how much we would have to change teacher salaries by to bring each country's PISA score up to the level of Finland (keeping class size constant). In the following section we look at making increases or decreases to class size, before finally exploring the prioritisation of these two policy choices.

Since Finland has proved to be at the frontier of efficiency, we fix Finland as our country of reference, assuming it operates at maximum efficiency, and so no variation in teacher salaries or pupil/teacher ratio is required. This is common practice, as many education ministers *de facto* make just such a comparison. In general, the analysis shows that in most developing countries a significant increase in teachers' wages would improve the relative performance of their education systems.

The top and bottom extremes of the table highlight an important point: inefficiency can be a result of either overpaying teachers (Switzerland and Belgium top the table) or underpaying teachers (Indonesia and Chile foot the table). These countries occupy 4 of the bottom 6 places in the overall efficiency rankings. This table can be used to diagnose where policy decisions on wages have potentially introduced system inefficiency in terms of producing high PISA scores.

A useful concept to introduce in relation to this point is peak efficiency. In a project to improve outcomes by increasing investment in a given education system, there will often be a point past which there is a weak rate of outcome-return on investment. (This investment may be in the form of teachers' salaries or increased teacher numbers.) The point of peak efficiency is the point past which a significant improvement in outcomes requires a very large increase in investment, relative to that delivered at lower levels of investment. Peak efficiency may be useful for policymakers to consider: if known, it can provide countries that have low levels of education investment with reason to increase this (up to peak efficiency); conversely, countries with high levels of investment and good educational outcomes may be able to carry out austerity programmes productively if they know that educational outcomes will not be significantly reduced by focused curtailment of investment.

If Switzerland, for example, were to decrease its teachers' salaries by 48.5 %, while maintaining the pupil/teacher ratio, it could sit alongside Finland near the top of the PISA rankings. This would of course have practical implications (e.g. decreasing the required education budget in this case). The challenge for policymakers whose systems occupy the top of the table and wish to drive up efficiency would be to balance the following considerations:

- To what extent will reducing wages impact on the quality of teaching staff? Is there a need to introduce or scale up recruitment strategies that can attract equally high performing teachers at a lower cost (e.g. Teach for America, Teach First etc.)?
- Conversely, is the wage set at the right level but teachers are not, by international comparison, producing the same level of pupil performance? In which case, teacher capacity, curricula and pedagogy may be the weak points in the system. i.e. the system should be producing more with the plentiful resources expended.
- What are we expecting from teachers? We have used PISA scores as the desired output variable in this study. If a system strives for other outcomes and therefore has different and more costly requirements of its teachers, then the extra spend may represent good value for money to that particular country. In that case, policymakers should be aware of, and have a well-defined specification of, what this premium on salaries buys them. If not, the system is potentially unnecessarily inefficient, and the points above merit exploration.

Figure 6 also shows that around half the countries studied would need to increase salaries to raise pupil attainment. The analysis does therefore suggest that these countries could, on average, potentially improve their PISA scores by spending more on recruiting higher-quality teachers. Indeed, the majority of countries in this bracket do find themselves at the lower end of the PISA rankings. Considerations are likely to be:

- What recruitment structure should be implemented to ensure that higher salaries do actually attract the right individuals rather than simply paying more for the same? Is salary the overriding factor in attracting highly skilled candidates? Or do other, perhaps cultural, barriers exist?
- Potentially, the system is successfully implementing high-quality curricula, teacher training programmes etc. so by comparison, teachers may be over-performing (although judging by PISA scores, this is not the case with those countries at the extreme). In this case, the sustainability of such a policy may be of concern (potentially to the Czech Republic).

Figure 6. Percentage change required in teacher salary to increase PISA score to the level of Finland (holding class size constant)

Note: The extreme figure for Indonesia is not drawn to facilitate the graphical comparison of countries.

Source: Table 3

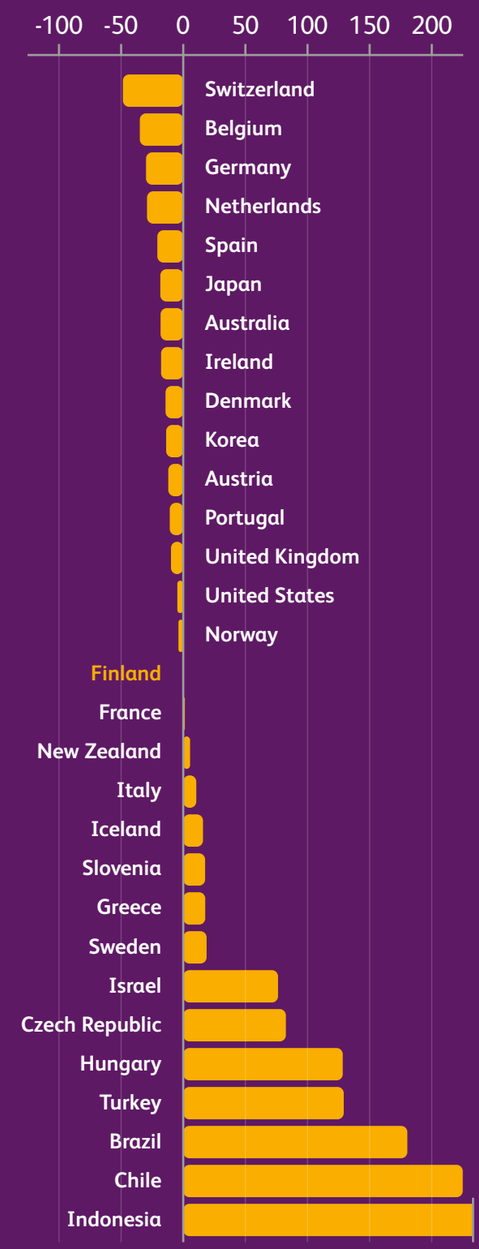


Table 3.

We have chosen to compare teachers' PPP (Purchasing Power Parity)[12] adjusted salaries, rather than a relative measure (e.g. by comparison to average national salaries). We do so because many assumptions are required to be able to use such relative measures, which thereby renders practical interpretations unclear. The availability of reliable data to make these assumptions is also questionable in the case of many countries. For the purposes of generating our efficiency index, we believe PPP-corrected values from the OECD provide a more accurate and fair international comparator.

	Current salary ($ PPP)	Target salary ($ PPP)	% increase to achieve target
Switzerland	68,820	35,470	-48.5
Belgium	51,470	33,500	-34.9
Germany	53,730	37,660	-29.9
Netherlands	57,870	41,010	-29.1
Spain	41,520	32,880	-20.8
Japan	45,930	37,460	-18.4
Australia	44,000	35,990	-18.2
Ireland	47,300	38,870	-17.8
Denmark	41,710	35,800	-14.2
Korea	47,340	40,870	-13.7
Austria	37,410	32,910	-12.0
Portugal	34,590	30,840	-10.8
United Kingdom	40,910	36,920	-9.8
United States	41,460	39,520	-4.7
Norway	33,130	31,860	-3.8
Finland	42,810	n/a	n/a
France	33,570	34,000	1.3
New Zealand	34,760	36,660	5.5
Italy	31,460	34,760	10.5
Iceland	29,480	34,170	15.9
Slovenia	32,480	38,210	17.6
Greece	25,750	30,310	17.7
Sweden	31,610	37,560	18.8
Israel	19,550	34,460	76.3
Czech Republic	18,610	33,990	82.6
Hungary	14,760	33,710	128.4
Turkey	17,180	39,380	129.2
Brazil	14,840	41,610	180.4
Chile	16,410	53,340	225.0
Indonesia	2,830	12,610	345.6

12 Purchasing Power Parities (PPPs) are the rates of currency conversion that eliminate the differences in price levels between countries.

A Point of Policy?

Class Sizes

➡ **PISA scores could also be improved** by varying the ratio of pupils to teachers.

➡ **The two most efficient systems (Finland and Korea)** have the 3rd and 5th largest pupil/teacher ratios (implies greater class sizes).

We now look at the other significant input variable and estimate how much each country would have to vary its pupil/teacher ratio in order to achieve Finland's PISA scores.

Class sizes are both a policy decision and a resource constraint. For a given number of pupils, the class size dictates how many teachers you need in the system and therefore what budget is required. It is worth reiterating that we are using the terms "class size" and "pupil/teacher ratio" interchangeably, when in fact there is a subtle difference[13]. It is also within leaders' power to vary class sizes without affecting the overall pupil/teacher ratio, most significantly via teaching contact time. The quantity of teachers required to teach pupil cohorts of a defined size will also impacted by the education model employed and the proportion of part-time staff.

Class size as it relates to quality of outcomes is well-debated in the existing literature. Here we present the theoretical targets to raise PISA scores, given each country's existing wage structure.

It is worth stressing that our research is not suggesting an ideal target figure for either teachers' salaries or pupil/teacher ratios. It is the combination of both these inputs and the resulting PISA score which drive efficiency. Our results are therefore contextual for each country. To produce Finland's attainment, there is an ideal combination of teacher salaries and pupil/teacher ratio – we have fixed each one of these in turn and calculated the required variation in the other. This variation would not be without cost implications. (As previously discussed, raw cost per pupil does not feature in our efficiency calculation.)

Take the example of Chile, who theoretically would need to reduce their pupil/teacher ratio to 1.97 – a drastic (and practically impossible) change. Chile has the 2nd highest class size as well as the 4th lowest teacher salaries. One would perhaps expect such input metrics to be good for efficiency, but resulting outcomes are so low as to create inefficiency (Chile ranks 20th on the efficiency index). Because both Chile's input variables lie at the extremes of the spectrum, holding one constant therefore requires a drastic change in the other to counteract it. In practice, improving efficiency for Chile would require changing both inputs to move the system closer to the "maximum" balance – the research suggests improved PISA scores will follow.

13 The reader is cautioned that the most commonly used measures – class size and Pupil/Teacher ratios - need to be treated with care as a high values of these 'inputs' mean obviously poorer resource levels for pupils and we would like to see lower levels of this inputs.

Figure 7. Percentage change in Pupil/Teacher Ratio required to increase PISA score to the level of Finland (holding teacher wage constant)

Source: Table 4

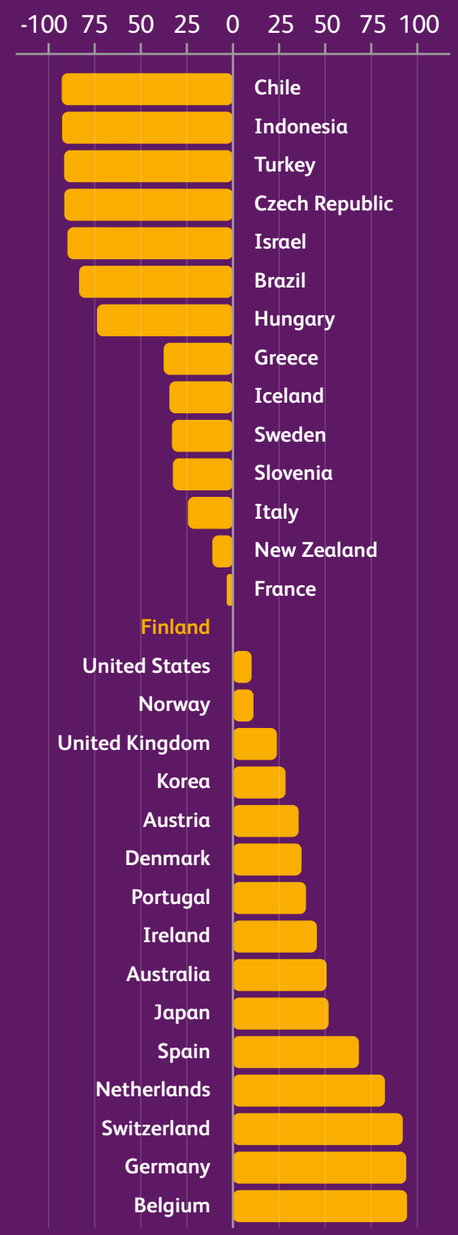


Table 4.

	Actual pupil/ teacher ratio	Target pupil/ teacher ratio	% change to achieve target
Chile	27.6	2.0	-92.9
Indonesia	17.4	1.3	-92.7
Turkey	16.4	1.4	-91.6
Czech Republic	12.3	1.0	-91.5
Israel	11.7	1.2	-89.8
Brazil	32.1	5.3	-83.5
Hungary	12.0	3.2	-73.8
Greece	9.7	6.1	-37.6
Iceland	10.9	7.1	-34.5
Sweden	14.4	9.6	-33.1
Slovenia	14.1	9.5	-32.6
Italy	10.8	8.2	-24.4
New Zealand	13.5	12.0	-11.2
France	10.4	10.1	-3.4
Finland	16.5	n/a	n/a
United States	15.3	16.8	10.1
Norway	9.2	10.2	11.1
United Kingdom	13.4	16.6	23.8
Korea	18.2	23.3	28.5
Austria	10.2	13.8	35.6
Denmark	12.7	17.4	37.2
Portugal	7.6	10.6	39.6
Ireland	14.8	21.6	45.5
Australia	12.6	19.0	50.8
Japan	13.1	19.8	51.9
Spain	10.1	17.0	68.3
Netherlands	16.4	29.9	82.4
Switzerland	11.6	22.3	92.1
Germany	13.7	26.5	94.0
Belgium	9.9	19.3	94.4

Policy Priorities

➡ **Inefficiency is caused** by sub-optimal teacher salaries, or class sizes, or a combination of both.

➡ **The extent to which varying either of these will have an impact is specific to each country.** Differing cultures, public opinion and political influences will impact on the practicality of implementing reforms.

Salaries and class sizes are typically chosen by education authorities based on administrative conventions and political directives from government. Changing them is an explicit option open to decision makers. The previous two sections demonstrate the relative power of a particular country varying one or other input. For example, we observe from our model that by international comparison, the UK could theoretically achieve Finland's PISA scores with a 23.8 % larger pupil/teacher ratio, or alternatively, just a 9.8 % decrease in teacher salaries. In contrast to this, the total educational spending envelope will likely be beyond education authorities' control. It will be predetermined by the aggregate level of economic growth and the fraction of a country's GDP that is devoted to educational expenditure.

> "This sort of approach to education – comparative, analytical, quantifiable – should be welcomed for the way it challenges us."
>
> **Russell Hobby,**
> General Secretary of the National Association of Head Teachers.

Politicians must work within the framework of the resources given to them to balance a policy's effectiveness with the practicalities of implementation. Put another way: politicians must aim to implement the most efficient and feasible policy for their country.

Our efficiency index is a product of three variables (2 inputs and 1 output). Changing one variable will have an effect specifically relevant in the context of the other two. Thus an appropriate strategy to drive efficiency in one system may have the opposite effect on another.

By looking at relative changes required in salaries and class size, we group countries according to implied policy priorities to raise educational outcomes, defined by:

1 Address class size
Although these systems could drive efficiency by lowering teacher salaries, little impact will be noticed unless drastic measures are taken, which is extremely unlikely in reality. However, all of these systems have smaller class sizes than Finland and Korea, suggesting this could be an appropriate strategy to drive efficiency and quality.

2 Address teacher salaries
Change in class size required would be impractically drastic. Systems should review teachers' salaries to drive efficiency and quality improvements.

3 Changing both class sizes and salaries could be effective
Relatively small changes in teacher salaries could produce Finland's PISA scores. Overnight reductions are unlikely to be suggested, whereas pay freezes are not unknown. Adjusting pupil/teacher ratios to is also an available option.

Table 5.

Group	Country	Priority pupil/teacher ratio or salaries	Current Average Salary	Target Average Salary	Current pupil/teacher ratio	Target pupil/teacher ratio
1	Australia	Pupil/teacher ratio	44	35.99	12.61	19.02
1	Austria	Pupil/teacher ratio	37.41	32.91	10.15	13.76
1	Belgium	Pupil/teacher ratio	51.47	33.5	9.94	19.32
2	Brazil	Teacher salaries	14.84	41.61	32.13	5.29
2	Chile	Teacher salaries	16.41	53.34	27.56	1.97
2	Czech Republic	Teacher salaries	18.61	33.99	12.27	1.04
1	Denmark	Pupil/teacher ratio	41.71	35.8	12.71	17.44
3	France	Both	33.57	34	10.43	10.08
1	Germany	Pupil/teacher ratio	53.73	37.66	13.68	26.54
2	Greece	Teacher salaries	25.75	30.31	9.73	6.07
2	Hungary	Teacher salaries	14.76	33.71	12.01	3.15
2	Iceland	Teacher salaries	29.48	34.17	10.88	7.13
2	Indonesia	Teacher salaries	2.83	12.61	17.39	1.27
1	Ireland	Pupil/teacher ratio	47.3	38.87	14.83	21.58
2	Israel	Teacher salaries	19.55	34.46	11.73	1.2
3	Italy	Both	31.46	34.76	10.81	8.17
1	Japan	Pupil/teacher ratio	45.93	37.46	13.06	19.84
1	Korea	Pupil/teacher ratio	47.34	40.87	18.17	23.34
1	Netherlands	Pupil/teacher ratio	57.87	41.01	16.38	29.88
3	New Zealand	Both	34.76	36.66	13.47	11.96
3	Norway	Both	33.13	31.86	9.19	10.21
1	Portugal	Pupil/teacher ratio	34.59	30.84	7.58	10.58
2	Slovenia	Teacher salaries	32.48	38.21	14.08	9.49
1	Spain	Pupil/teacher ratio	41.52	32.88	10.11	17.02
2	Sweden	Teacher salaries	31.61	37.56	14.38	9.62
1	Switzerland	Pupil/teacher ratio	68.82	35.47	11.6	22.28
2	Turkey	Teacher salaries	17.18	39.38	16.38	1.38
3	UK	Both	40.91	36.92	13.4	16.59
3	USA	Both	41.46	39.52	15.29	16.84

Efficiency vs Quality

- **In general, countries demonstrating high efficiency** also attain high education outcomes.
- **Efficiency is a very important metric to consider** – some countries may wish to prioritise efficiency over quality. For others, the opposite is true. Country context will dictate this.

Having computed our efficiency scores it is important to consider the emphasis policy makers should place on them, given the highly context-specific nature of education systems. Salient questions are: to what extent is there a relationship between efficiency scores and quality (PISA scores)? To what extent can variation in attainment be explained by educational system efficiency? Should countries strive for efficiency or absolute quality at any cost? Clearly a country's economic status will influence the freedom available in making this choice, but how should available resources be prioritised?

Hungary and Switzerland are good examples of this trade-off:

- Hungary scores very well on the efficiency index, but poorly when it comes to producing results.
- Switzerland is the opposite – its PISA scores are among the best, but at huge cost, resulting in a poor efficiency ranking.

These are two extremes, but the consideration exists for all countries: some are in the fortunate position to be able to focus on outcomes, because resources are plentiful. Customers buying luxury sports cars are not likely to be concerned with fuel efficiency; they can choose to prioritise other desirable features and are prepared to pay higher fuel costs for the privilege. It is very possible that some education systems are similarly paying a premium for additional outcomes beyond PISA scores. Although providing an excellent method of comparing educational attainment across borders, they cannot measure every output of the system. In such cases, inefficiency may not be considered a problem, but these additional outcomes must be known and desired. If they are unknown, inefficiency should be explored. Most countries have to squeeze as much as possible out of what little they have and not endanger financial stability, perhaps at the cost of putting a ceiling on outcomes. Regardless, all countries would obviously like to achieve more with what they currently have.

From the simple linear regression overleaf (Figure 8b) we can infer that 44 % of the variation in the PISA score can be explained by the variation in the efficiency index scores across countries. This suggests that a significant fraction of the heterogeneity of educational systems can be explained by the way in which each country combines teacher quality and class size to achieve its educational goals. Other factors are obviously influential (61 for which we tested – see Annex D3), but none are statistically significant in the way that teacher salaries and the pupil/teacher ratio are. In addition, there are other factors for which no metrics exist. Context should always be considered when making statistical comparisons internationally; cultural differences can result in significantly different levels of support in addition to formal schooling. For example, the quantity of tutoring received out of school time is not considered as a system input, but will contribute to the output (pupil attainment via PISA scores). We explore private tutoring in Annex B.

Figure 8a. Group definitions for Correlation between Efficiency and Quality

The ambition of every system is to move as far into the top right quadrant as possible, i.e. high efficiency and high outcomes. For some this will mean prioritising quality over efficiency. For others the reverse will be true. The following groupings are defined according to this balance, implied by position on the graph.

GROUP 1
Elite Performers

There is always room for improvement despite the fact that these countries score well in both the efficiency and quality stakes.

1 Finland | 2 Japan | 3 Korea

GROUP 2
Efficient and Effective

These countries are doing relatively well on both efficiency and producing high PISA scores. They are not in the Elite benchmark countries but they are close.

14 Australia | 15 Czech Republic | 20 New Zealand | 22 Slovenia

GROUP 3
More Effective than Efficient : Overspending or bloated

These countries perform better in quality measures than in terms of efficiency. This may be because they can prioritise outcomes over cost, it may be because their system generates other outcomes that aren't captured by PISA rankings. Or more simply, it may be because the system is over-resourced beyond a threshold required to drive quality increases.

4 Austria | 5 Belgium | 6 Denmark | 7 Germany | 8 Ireland | 9 Italy
10 Netherlands | 11 Portugal | 12 Spain | 13 Switzerland

GROUP 4
More Efficient than Effective: Underspending or underperforming

These countries, by comparison, are more efficient than educationally effective. This could be for the simple reason that they have constraints which prevent their system from moving to the next level (e.g. low salaries may prevent the teaching profession from being able to recruit highly skilled individuals). More interestingly, if extensive resources are already being deployed, it could be the case that underlying flaws exist in the education delivery model – the system has the potential to increase outputs for no additional inputs by making policy changes.

16 France | 17 Hungary | 18 Iceland | 19 Israel | 21 Norway | 23 Sweden | 24 UK | 25 USA

GROUP 5
Inefficient and Ineffective

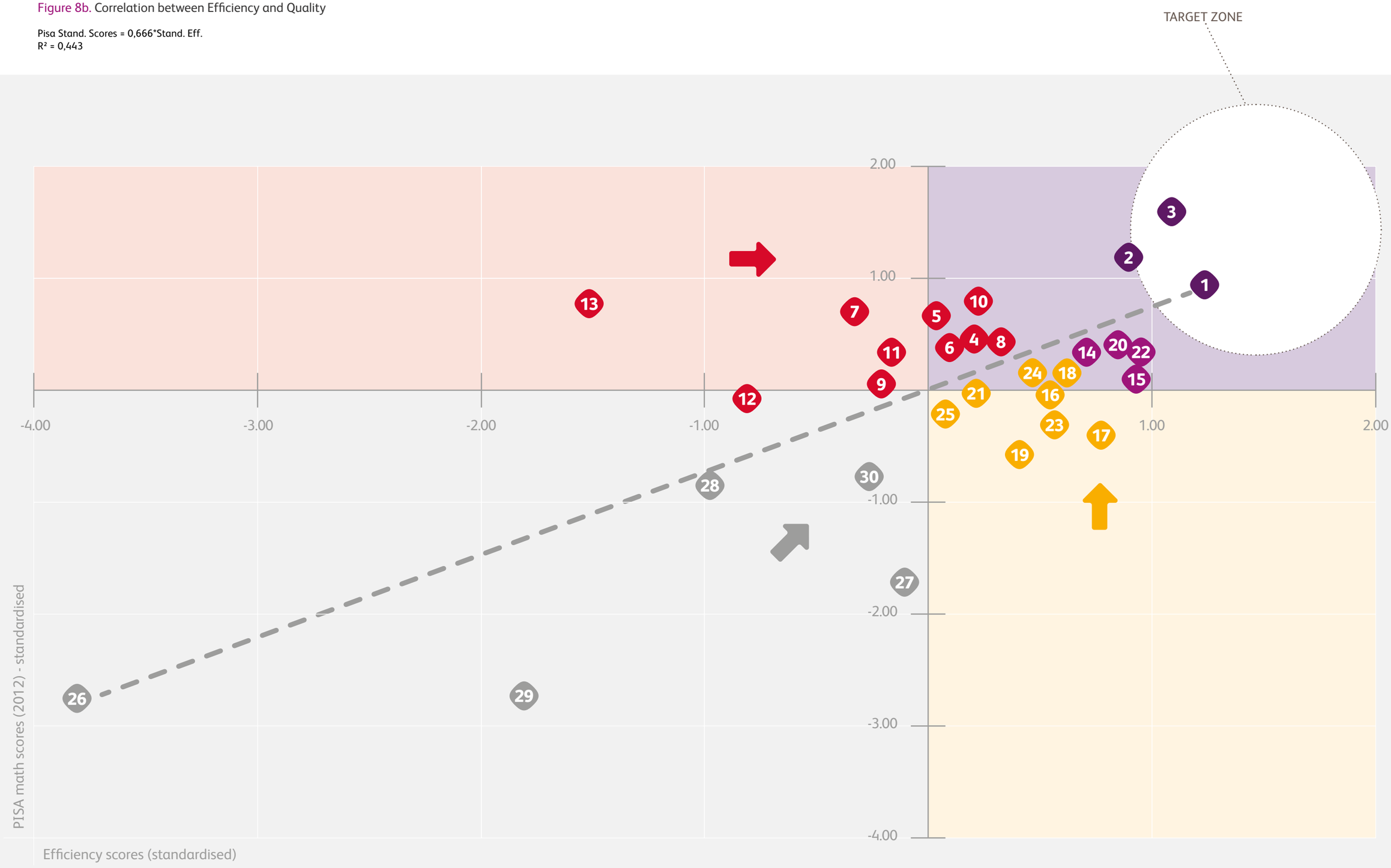
These systems are inefficient and at the same time do not produce comparatively good outcomes. The ultimate ambition is to occupy a space in the upper-right quadrant, but progression either horizontally or vertically (increasing quality or efficiency) in the first instance could be the catalyst to drive improvements in both dimensions.

26 Brazil | 27 Chile | 28 Greece | 29 Indonesia | 30 Turkey

See next page for Figure 8b. Correlation between Efficiency and Quality.

Figure 8b. Correlation between Efficiency and Quality

Pisa Stand. Scores = 0,666*Stand. Eff.
R^2 = 0,443



Conclusion

- **Historically, education systems were compared** by levels of input before comparators such as PISA, TIMMS, PIRLS shifted the focus to outputs.
- **Correlations have been explored between these inputs and outputs,** but there is still much progress to be made in being able to explain the practical strategies and policies which can be implemented to vary inputs and increase outputs. The Efficiency Index aims to fuel this debate.

In PISA, TIMMS and PIRLS we now have well established international benchmarks for education outcomes. We also have an increasing quantity of high-quality data on numerous other aspects of education delivery: from literacy rates to teacher compensation to funding arrangements, the list of available metrics is lengthy. We are in an era in which education studies and research can move beyond simple rankings of single indicators. Much good work has been done to identify correlations between education system inputs and outputs. Fundamentally, however, data and analysis must demonstrate how fit for purpose education systems are – whatever that purpose may be – before seeking to explain how this is achieved.

Our analysis only examined OECD countries, but the message is potentially even more relevant to young and less well-developed systems. It shows that the top systems in the world, although adopting different methods, are actually very similar in a few key policy areas. It also shows that finding ways to generate greater inputs may not be the system's most urgent need: more can be done with less. The issue is not always what tools you have, but how you use them.

The Efficiency Index challenges policymakers to think differently. What if the motor industry had just accepted that petrol engines were the only option? What if engineers accepted engines as being black boxes, tinkering around the edges but making no significant modifications? The hybrid car would never have been developed. Rather, the industry modernises in search of efficiency; alternative power sources are designed to address the problem. Accepting and identifying drivers of inefficiency has to be the first stage in the process.

Education systems are complex. International comparisons will never be perfect: cultural, political, and socio-economic factors all contribute to varying degrees in each country. We have focused on one output, but the choice of this output in each context is an important part of the debate. Data can help, but sophisticated indicators are needed. The more light we can shed on the policies and strategies that are within our power to change, the more effectively education systems can play their role in the society of the future. If we are to demand modernisation and reform of education systems, the way in which they are measured must also reflect this; the Efficiency Index is just the start.

COUNTRY PROFILES

Sources:

Teacher salaries and pupil/teacher ratio:
Authors' calculations

PISA scores:
OECD, Education at a Glance
(2012 scores)

Key country indicators:
World Bank DataBank (Population and GDP per capita – 2013 unless otherwise stated. Public expenditure on education as a % of GDP – 2010 unless otherwise stated)

8th

AUSTRALIA

Efficiency Index
81.23%

$44,000
Actual salary

$35,990
Target salary

-18.2%
Change to achieve target

TEACHER SALARIES

12.6
Actual pupil/teacher ratio

19.0
Target pupil/teacher ratio

50.8%
Change to achieve target

PUPIL/TEACHER RATIO

504
PISA Maths 2012

512
PISA Reading 2012

521
PISA Science 2012

PISA SCORES

Australia ranks in the Top Ten of the Efficiency Index at 81.23% -- just slightly below its neighbour, New Zealand

Our findings suggest that Australia should consider addressing class sizes to target education efficiency

Australia's education system is a good performer, although it appears to be slightly more efficient than effective

Key Country Indicators

23.13m	$43,550	5.59 %
Population	GDP per capita (PPP)	Public expenditure on education as % of GDP

16th

AUSTRIA

Efficiency Index
74.68%

$37,410
Actual salary

$32,910
Target salary

-12.0%
Change to achieve target

TEACHER SALARIES

10.2
Actual pupil/teacher ratio

13.8
Target pupil/teacher ratio

35.6%
Change to achieve target

PUPIL/TEACHER RATIO

506
PISA Maths 2012

490
PISA Reading 2012

506
PISA Science 2012

PISA SCORES

Austria ranks in the middle of the Efficiency Index at 74.68% -- a score that is notably more efficient than its neighbour, Germany, but also in keeping with some other Western and Northern European countries' scores, such as those for Belgium, Norway, Ireland and The Netherlands

Our findings suggest that Austria should consider addressing class sizes to target education efficiency

Austria's education system appears to be more effective than efficient. It may be bloated or overspending

Key Country Indicators

8.47m	$44,168	5.91 %
Population	GDP per capita (PPP)	Public expenditure on education as % of GDP

18th

BELGIUM

Efficiency Index
73.52%

$51,470
Actual salary

$33,500
Target salary

-34.9%
Change to achieve target

TEACHER SALARIES

9.9
Actual pupil/teacher ratio

19.3
Target pupil/teacher ratio

94.4%
Change to achieve target

PUPIL/TEACHER RATIO

515
PISA Maths 2012

509
PISA Reading 2012

505
PISA Science 2012

PISA SCORES

Belgium's Efficiency Index score of 73.52% is close to the bottom third of the Index, and sits midway between the rankings of bordering countries, France, The Netherlands and Germany

Our findings suggest that Belgium should consider addressing class sizes to target education efficiency

Belgium's education system appears to be more effective than efficient. It may be bloated or overspending

Key Country Indicators

11.20m	$40,338	6.58 %
Population	GDP per capita (PPP)	Public expenditure on education as % of GDP

30th

BRAZIL

Efficiency Index
25.45%

$14,840
Actual salary

$41,610
Target salary

180.4%
Change to achieve target

TEACHER SALARIES

32.1
Actual pupil/teacher ratio

5.3
Target pupil/teacher ratio

-83.5%
Change to achieve target

PUPIL/TEACHER RATIO

391
PISA Maths 2012

410
PISA Reading 2012

405
PISA Science 2012

PISA SCORES

Brazil ranks at the very bottom of the Efficiency Index, with a score of 25.45%, significantly below other countries in the Index

Our findings suggest that Brazil should consider addressing teacher salaries to target education efficiency

Brazil's education system is both inefficient and ineffective. Higher efficiency correlates with higher educational outcomes

Key Country Indicators

200.36m	$15,034	5.82 %
Population	GDP per capita (PPP)	Public expenditure on education as % of GDP

CHILE

Efficiency Index
72.54%

$16,410
Actual salary

$53,340
Target salary

225.0%
Change to achieve target

TEACHER SALARIES

27.6
Actual pupil/teacher ratio

2.0
Target pupil/teacher ratio

-92.9%
Change to achieve target

PUPIL/TEACHER RATIO

423
PISA Maths 2012

441
PISA Reading 2012

445
PISA Science 2012

PISA SCORES

Chile sits just inside the bottom third of the Efficiency Index with a score of 72.54%, which is a significantly higher ranking than its South American neighbour, Brazil

Our findings suggest that Chile should consider addressing teacher salaries to target education efficiency

Chile's education system is both inefficient and ineffective. Higher efficiency correlates with higher educational outcomes

Key Country Indicators

17.62m	$21,911	4.18 %
Population	GDP per capita (PPP)	Public expenditure on education as % of GDP

CZECH REPUBLIC

Efficiency Index
84.38%

$18,610
Actual salary

$33,990
Target salary

82.6%
Change to achieve target

TEACHER SALARIES

12.3
Actual pupil/teacher ratio

1.0
Target pupil/teacher ratio

-91.5%
Change to achieve target

PUPIL/TEACHER RATIO

499
PISA Maths 2012

493
PISA Reading 2012

508
PISA Science 2012

PISA SCORES

The Czech Republic ranks in the top 3 of the Efficiency Index with a laudable score of 84.38%, significantly higher than neighbouring countries Germany and Austria

Our findings suggest that Czech Republic should consider addressing teacher salaries to target education efficiency

The Czech Republic's education system is a good performer, although it appears to be slightly more efficient than effective

Key Country Indicators

10.52m	$27,344	4.25 %
Population	GDP per capita (PPP)	Public expenditure on education as % of GDP

22nd

DENMARK

Efficiency Index
70.60%

$41,710
Actual salary

$35,800
Target salary

-14.2%
Change to achieve target

TEACHER SALARIES

12.7
Actual pupil/teacher ratio

17.4
Target pupil/teacher ratio

37.2%
Change to achieve target

PUPIL/TEACHER RATIO

500
PISA Maths 2012

496
PISA Reading 2012

498
PISA Science 2012

PISA SCORES

Denmark ranks in the bottom third of the Efficiency Index, at 70.60%, below its Scandinavian neighbours Norway, Iceland, Sweden and Finland

Our findings suggest that Denmark should consider addressing class sizes to target education efficiency

Denmark's education system appears to be more effective than efficient. It may be bloated or overspending

Key Country Indicators

5.61m	$42,790	8.74 %*
Population	GDP per capita (PPP)	Public expenditure on education as % of GDP

* 2009

1st

FINLAND

Efficiency Index
87.81%

$42,810
Actual salary

n/a
Target salary

n/a
Change to achieve target

TEACHER SALARIES

16.5
Actual pupil/teacher ratio

n/a
Target pupil/teacher ratio

n/a
Change to achieve target

PUPIL/TEACHER RATIO

519
PISA Maths 2012

524
PISA Reading 2012

545
PISA Science 2012

PISA SCORES

Finland has earned the top Efficiency Index ranking, with a score of 87.81%

Our analysis finds that Finland's education system is the most efficient amongst OECD countries

Finland is a high performer in both the efficiency and quality stakes

Key Country Indicators

5.44m	$38,251	6.85 %
Population	GDP per capita (PPP)	Public expenditure on education as % of GDP

12th

FRANCE

Efficiency Index
78.69%

$33,570
Actual salary

$34,000
Target salary

1.3%
Change to achieve target

TEACHER SALARIES

10.4
Actual pupil/teacher ratio

10.1
Target pupil/teacher ratio

-3.4%
Change to achieve target

PUPIL/TEACHER RATIO

495
PISA Maths 2012

505
PISA Reading 2012

499
PISA Science 2012

PISA SCORES

France ranks in the top half of the Efficiency Index, and second amongst other Western European countries profiled

Our findings suggest that France should consider addressing both class sizes and teacher salaries to target education efficiency

France's education system appears to be more efficient than effective. It may be underspending or underperforming

Key Country Indicators

66.03m	$36,907	5.86 %
Population	GDP per capita (PPP)	Public expenditure on education as % of GDP

25th

GERMANY

Efficiency Index
67.01%

$53,730
Actual salary

$37,660
Target salary

-29.9%
Change to achieve target

TEACHER SALARIES

13.7
Actual pupil/teacher ratio

26.5
Target pupil/teacher ratio

94.0%
Change to achieve target

PUPIL/TEACHER RATIO

514
PISA Maths 2012

508
PISA Reading 2012

524
PISA Science 2012

PISA SCORES

Germany ranks close to the bottom of the Efficiency Index. Of the six bordering countries, that feature on the Index, only Switzerland is ranked lower

Our findings suggest that Germany should consider addressing class sizes to target education efficiency

Germany's education system appears to be more effective than efficient. It may be bloated or overspending

Key Country Indicators

80.62m	$43,332	5.08 %
Population	GDP per capita (PPP)	Public expenditure on education as % of GDP

27th

GREECE

Efficiency Index
60.64%

$25,750
Actual salary

$30,310
Target salary

17.7%
Change to achieve target

TEACHER SALARIES

9.7
Actual pupil/teacher ratio

6.1
Target pupil/teacher ratio

-37.6%
Change to achieve target

PUPIL/TEACHER RATIO

453
PISA Maths 2012

477
PISA Reading 2012

467
PISA Science 2012

PISA SCORES

Greece ranks at the bottom 5 of the Efficiency Index, and below the other Southern European countries profiled

Our findings suggest that Greece should consider addressing teacher salaries to target education efficiency

Greece's education system appears to be more effective than efficient. It may be bloated or overspending

Key Country Indicators

11.03m	$25,651	4.09 % *
Population	GDP per capita (PPP)	Public expenditure on education as % of GDP

* 2005

4th

HUNGARY

Efficiency Index
84.08%

$14,760
Actual salary

$33,710
Target salary

128.4%
Change to achieve target

TEACHER SALARIES

12.0
Actual pupil/teacher ratio

3.2
Target pupil/teacher ratio

-73.8%
Change to achieve target

PUPIL/TEACHER RATIO

477
PISA Maths 2012

488
PISA Reading 2012

494
PISA Science 2012

PISA SCORES

Hungary ranked very high on the Efficiency Index, and in between other Eastern European countries, Slovenia and the Czech Republic

Our findings suggest that Hungary should consider addressing teacher salaries to target education efficiency

Hungary's education system appears to be more efficient than effective. It may be underspending or underperforming

Key Country Indicators

9.90m	$22,190*	4.90 %
Population	GDP per capita (PPP)	Public expenditure on education as % of GDP

* 2012

10th

ICELAND

Efficiency Index
79.39%

$29,480
Actual salary

$34,170
Target salary

15.9%
Change to achieve target

TEACHER SALARIES

10.9
Actual pupil/teacher ratio

7.1
Target pupil/teacher ratio

-34.5%
Change to achieve target

PUPIL/TEACHER RATIO

493
PISA Maths 2012

483
PISA Reading 2012

478
PISA Science 2012

PISA SCORES

Iceland ranks just within the Top 10 behind Sweden and Finland but above Norway and Denmark

Our findings suggest that Iceland should consider addressing teacher salaries to target education efficiency

Iceland's education system appears to be more efficient than effective. It may be underspending or underperforming

Key Country Indicators

0.32m	$39,996	7.60 %
Population	GDP per capita (PPP)	Public expenditure on education as % of GDP

29th

INDONESIA

Efficiency Index
51.13%

$2,830
Actual salary

$12,610
Target salary

345.6%
Change to achieve target

TEACHER SALARIES

17.4
Actual pupil/teacher ratio

1.3
Target pupil/teacher ratio

-92.7%
Change to achieve target

PUPIL/TEACHER RATIO

375
PISA Maths 2012

396
PISA Reading 2012

382
PISA Science 2012

PISA SCORES

Indonesia holds the second-bottom ranking on the Efficiency Index, ahead of only Brazil

Our findings suggest that Indonesia should consider addressing teacher salaries to target education efficiency

Indonesia's education system is both inefficient and ineffective. Higher efficiency correlates with higher educational outcomes

Key Country Indicators

249.87m	$9,559	2.99 %
Population	GDP per capita (PPP)	Public expenditure on education as % of GDP

15th

IRELAND

Efficiency Index
76.80%

$47,300
Actual salary

$38,870
Target salary

-17.8%
Change to achieve target

TEACHER SALARIES

14.8
Actual pupil/teacher ratio

21.6
Target pupil/teacher ratio

45.5%
Change to achieve target

PUPIL/TEACHER RATIO

501
PISA Maths 2012

523
PISA Reading 2012

522
PISA Science 2012

PISA SCORES

Ireland ranks right in the middle of the Efficiency Index, at 76.80%

Our findings suggest that Ireland should consider addressing class sizes to target education efficiency

Ireland's education system appears to be more effective than efficient. It may be bloated or overspending

Key Country Indicators

4.60m	$43,304	6.41 %
Population	GDP per capita (PPP)	Public expenditure on education as % of GDP

13th

ISRAEL

Efficiency Index
51.13%

$19,550
Actual salary

$34,460
Target salary

76.3%
Change to achieve target

TEACHER SALARIES

11.7
Actual pupil/teacher ratio

1.2
Target pupil/teacher ratio

-89.8%
Change to achieve target

PUPIL/TEACHER RATIO

466
PISA Maths 2012

486
PISA Reading 2012

470
PISA Science 2012

PISA SCORES

Israel is the only Middle Eastern country that has been profiled in the Efficiency Index, and ranks just above the median

Our findings suggest that Israel should consider addressing teacher salaries to target education efficiency

Israel's education system appears to be more efficient than effective. It may be underspending or underperforming

Key Country Indicators

8.06m	$32,760	5.59 %
Population	GDP per capita (PPP)	Public expenditure on education as % of GDP

ITALY

Efficiency Index
69.81%

$31,460
Actual salary
$34,760
Target salary
10.5%
Change to achieve target
TEACHER SALARIES

10.8
Actual pupil/teacher ratio
8.2
Target pupil/teacher ratio
-24.4%
Change to achieve target
PUPIL/TEACHER RATIO

485
PISA Maths 2012
490
PISA Reading 2012
494
PISA Science 2012
PISA SCORES

Italy ranks rather low on the Efficiency Index, and between other Southern European countries, Turkey and Greece

Our findings suggest that Italy should consider addressing both class sizes and teacher salaries to target education efficiency

Italy's education system appears to be more effective than efficient. It may be bloated or overspending

Key Country Indicators

59.83m	$34,303	4.50 %
Population	GDP per capita (PPP)	Public expenditure on education as % of GDP

JAPAN

Efficiency Index
83.88%

$45,930
Actual salary
$37,460
Target salary
-18.4%
Change to achieve target
TEACHER SALARIES

13.1
Actual pupil/teacher ratio
19.8
Target pupil/teacher ratio
51.9%
Change to achieve target
PUPIL/TEACHER RATIO

536
PISA Maths 2012
538
PISA Reading 2012
547
PISA Science 2012
PISA SCORES

Japan ranks among the Top 5 of the Efficiency Index, yet still ranks lower than Korea, the only other Asian country profiled

Our findings suggest that Japan should consider addressing class sizes to target education efficiency

Japan is a high performer in both the efficiency and quality stakes

Key Country Indicators

127.34m	$36,315	3.78 %
Population	GDP per capita (PPP)	Public expenditure on education as % of GDP

2nd

KOREA

Efficiency Index
86.66%

$47,340
Actual salary

$40,870
Target salary

-13.7%
Change to achieve target

TEACHER SALARIES

18.2
Actual pupil/teacher ratio

23.3
Target pupil/teacher ratio

28.5%
Change to achieve target

PUPIL/TEACHER RATIO

554
PISA Maths 2012

536
PISA Reading 2012

538
PISA Science 2012

PISA SCORES

Korea ranks second on the Efficiency Index, with a score of 86.66%

Our findings suggest that Korea should consider addressing class sizes to target education efficiency

Korea is a high performer in both the efficiency and quality stakes

Key Country Indicators

50.22m	$33,140	5.25 %*
Population	GDP per capita (PPP)	Public expenditure on education as % of GDP

* 2011

14th

NETHERLANDS

Efficiency Index
76.80%

$57,870
Actual salary

$41,010
Target salary

-29.1%
Change to achieve target

TEACHER SALARIES

16.4
Actual pupil/teacher ratio

29.9
Target pupil/teacher ratio

82.4%
Change to achieve target

PUPIL/TEACHER RATIO

523
PISA Maths 2012

511
PISA Reading 2012

522
PISA Science 2012

PISA SCORES

The Netherlands ranked in the middle of the Efficiency Index, and higher than its bordering countries, Germany and Belgium

Our findings suggest that Netherlands should consider addressing class sizes to target education efficiency

The Netherlands's education system appears to be more effective than efficient. It may be bloated or overspending

Key Country Indicators

16.80m	$43,404	5.98 %
Population	GDP per capita (PPP)	Public expenditure on education as % of GDP

6th

NEW ZEALAND

Efficiency Index
83.30%

$34,760
Actual salary

$36,660
Target salary

5.5%
Change to achieve target

TEACHER SALARIES

13.5
Actual pupil/teacher ratio

12.0
Target pupil/teacher ratio

-11.2%
Change to achieve target

PUPIL/TEACHER RATIO

500
PISA Maths 2012

512
PISA Reading 2012

516
PISA Science 2012

PISA SCORES

New Zealand ranks highly on the Efficiency Index, and slightly above its neighbour, Australia

Our findings suggest that New Zealand should consider addressing both class sizes and teacher salaries to target education efficiency

New Zealand's education system is a good performer, although it appears to be slightly more efficient than effective

Key Country Indicators

4.47m	$34,227	7.17 %
Population	GDP per capita (PPP)	Public expenditure on education as % of GDP

17th

NORWAY

Efficiency Index
74.05%

$33,130
Actual salary

$31,860
Target salary

-3.8%
Change to achieve target

TEACHER SALARIES

9.2
Actual pupil/teacher ratio

10.2
Target pupil/teacher ratio

11.1%
Change to achieve target

PUPIL/TEACHER RATIO

489
PISA Maths 2012

504
PISA Reading 2012

495
PISA Science 2012

PISA SCORES

Norway places in the bottom half of the Efficiency Index, and lower than all other Northern European countries except Denmark

Our findings suggest that Norway should consider addressing both class sizes and teacher salaries to target education efficiency

Norway's education system appears to be more efficient than effective. It may be underspending or underperforming

Key Country Indicators

5.08m	$65,461	6.87 %
Population	GDP per capita (PPP)	Public expenditure on education as % of GDP

24th

PORTUGAL

Efficiency Index
68.29%

$34,590
Actual salary

$30,840
Target salary

-10.8%
Change to achieve target

TEACHER SALARIES

7.6
Actual pupil/teacher ratio

10.6
Target pupil/teacher ratio

39.6%
Change to achieve target

PUPIL/TEACHER RATIO

487
PISA Maths 2012

488
PISA Reading 2012

489
PISA Science 2012

PISA SCORES

Portugal ranks in the bottom third of the Efficiency Index, lower than all other Mediterranean countries

Our findings suggest that Portugal should consider addressing class sizes to target education efficiency

Portugal's education system appears to be more effective than efficient. It may be bloated or overspending

Key Country Indicators

10.46m	$25,892	5.62 %
Population	GDP per capita (PPP)	Public expenditure on education as % of GDP

7th

SLOVENIA

Efficiency Index
83.28%

$32,480
Actual salary

$38,210
Target salary

17.6%
Change to achieve target

TEACHER SALARIES

14.1
Actual pupil/teacher ratio

9.5
Target pupil/teacher ratio

-32.6%
Change to achieve target

PUPIL/TEACHER RATIO

501
PISA Maths 2012

481
PISA Reading 2012

514
PISA Science 2012

PISA SCORES

Slovenia ranks in the Top 10 of the Efficiency Index, yet still lower than its Eastern European neighbours, the Czech Republic and Hungary

Our findings suggest that Slovenia should consider addressing teacher salaries to target education efficiency

Slovenia's education system is a good performer, although it appears to be slightly more efficient than effective

Key Country Indicators

2.06m	$27,915*	5.69 %
Population	GDP per capita (PPP)	Public expenditure on education as % of GDP

* 2012

26th

SPAIN

Efficiency Index
63.09%

$41,520
Actual salary

$32,880
Target salary

-20.8%
Change to achieve target

TEACHER SALARIES

10.1
Actual pupil/teacher ratio

17.0
Target pupil/teacher ratio

68.3%
Change to achieve target

PUPIL/TEACHER RATIO

484
PISA Maths 2012

488
PISA Reading 2012

496
PISA Science 2012

PISA SCORES

Spain ranks close to the bottom of the Efficiency Index, with only Switzerland ranking lower amongst other Western European countries

Our findings suggest that Spain should consider addressing class sizes to target education efficiency

Spain's education system appears to be more effective than efficient. It may be bloated or overspending

Key Country Indicators

46.65m	$32,103	4.98 %
Population	GDP per capita (PPP)	Public expenditure on education as % of GDP

9th

SWEDEN

Efficiency Index
80.58%

$31,610
Actual salary

$37,560
Target salary

18.8%
Change to achieve target

TEACHER SALARIES

14.4
Actual pupil/teacher ratio

9.6
Target pupil/teacher ratio

-33.1%
Change to achieve target

PUPIL/TEACHER RATIO

478
PISA Maths 2012

483
PISA Reading 2012

485
PISA Science 2012

PISA SCORES

Sweden ranks in the Top 10 of the Efficiency Index, and above all other Northern European countries, except Finland

Our findings suggest that Sweden should consider addressing teacher salaries to target education efficiency

Sweden's education system appears to be more efficient than effective. It may be underspending or underperforming

Key Country Indicators

9.59m	$43,455	6.98 %
Population	GDP per capita (PPP)	Public expenditure on education as % of GDP

28th

SWITZERLAND

Efficiency Index
59.71%

$68,820
Actual salary

$35,470
Target salary

-48.5%
Change to achieve target

TEACHER SALARIES

11.6
Actual pupil/teacher ratio

22.3
Target pupil/teacher ratio

92.1%
Change to achieve target

PUPIL/TEACHER RATIO

531
PISA Maths 2012

509
PISA Reading 2012

515
PISA Science 2012

PISA SCORES

Switzerland ranks extremely low on the Efficiency Index, lowest among all European countries

Our findings suggest that Switzerland should consider addressing class sizes to target education efficiency

Switzerland's education system appears to be more effective than efficient. It may be bloated or overspending

Key Country Indicators

8.08m	$53,705	5.24 %
Population	GDP per capita (PPP)	Public expenditure on education as % of GDP

21st

TURKEY

Efficiency Index
71.44%

$17,180
Actual salary

$39,380
Target salary

129.2%
Change to achieve target

TEACHER SALARIES

16.4
Actual pupil/teacher ratio

1.4
Target pupil/teacher ratio

-91.6%
Change to achieve target

PUPIL/TEACHER RATIO

448
PISA Maths 2012

475
PISA Reading 2012

463
PISA Science 2012

PISA SCORES

Turkey ranks fairly low on the Efficiency Index, yet still higher than the other Southern European countries

Our findings suggest that Turkey should consider addressing teacher salaries to target education efficiency

Turkey's education system is both inefficient and ineffective. Higher efficiency correlates with higher educational outcomes

Key Country Indicators

74.93m	$18,975	2.86 %*
Population	GDP per capita (PPP)	Public expenditure on education as % of GDP

* 2006

11th

UNITED KINGDOM

Efficiency Index
78.71%

$40,910
Actual salary

$36,920
Target salary

-9.8%
Change to achieve target

TEACHER SALARIES

13.4
Actual pupil/teacher ratio

16.6
Target pupil/teacher ratio

23.8%
Change to achieve target

PUPIL/TEACHER RATIO

494
PISA Maths 2012

499
PISA Reading 2012

514
PISA Science 2012

PISA SCORES

The UK ranks just outside the Top 10 on the Efficiency Index, but the highest among other Western European countries

Our findings suggest that United Kingdom should consider addressing both class sizes and teacher salaries to target education efficiency

The United Kingdom's education system appears to be more efficient than effective. It may be underspending or underperforming

Key Country Indicators

64.10m	$36,209	6.23 %
Population	GDP per capita (PPP)	Public expenditure on education as % of GDP

19th

UNITED STATES

Efficiency Index
72.66%

$41,460
Actual salary

$39,520
Target salary

-4.7%
Change to achieve target

TEACHER SALARIES

15.3
Actual pupil/teacher ratio

16.8
Target pupil/teacher ratio

10.1%
Change to achieve target

PUPIL/TEACHER RATIO

481
PISA Maths 2012

498
PISA Reading 2012

497
PISA Science 2012

PISA SCORES

The United States ranks in the lower half of the Efficiency Index, just above Chile

Our findings suggest that United States should consider addressing both class sizes and teacher salaries to target education efficiency

The United States's education system appears to be more efficient than effective. It may be underspending or underperforming

Key Country Indicators

316.13m	$53,143	5.42 %
Population	GDP per capita (PPP)	Public expenditure on education as % of GDP

Annex A
Strategies Combined

While we have already looked at the specific changes individual countries would have to make to improve efficiency, in this section we examine the average behaviour of all countries, to gain some insight into how drastic a variation in key inputs would have to be in order to drive up PISA scores.

We find that on average across all countries in our study, a 2 % rise in PISA scores could be achieved by:

- Increasing teacher wages by 6 % and not changing class size, or
- Lowering class size by 5 pupils (and not changing the teacher wage).

Likewise, our econometric model predicts that to achieve a 5 % rise in PISA scores it would take:

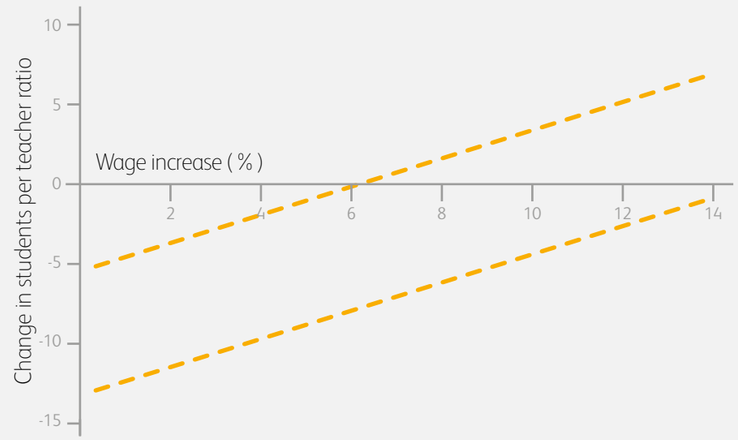
- A 14 % rise in teacher wages (holding class size constant), or
- A reduction by 13 pupils in average class size (holding teacher wages constant)

The graph below (Figure A1) maps out all such combinations of teacher wage rises and class size variations that would ensure a 2 % or 5 % rise in PISA scores. The example point highlighted on the graph shows that on average, a 5 % increase in PISA scores could be achieved by a combination of increasing teachers' salaries by 6 % and decreasing the number of pupils per teacher by 8.

The reader should be warned at this juncture that this diagram is slightly unusual and needs to be read with care. Those familiar with production function isoquants will observe that such trade-offs in inputs are usually non-linear and parabolic in shape. Unfortunately our data is not rich enough to identify such non-linearities and hence we have less confidence in the trade-offs at the extremes – i.e. especially in the case of the numerical examples given above. We would accordingly have more confidence in the trade-off we have graphically displayed in the middle area when the linear function estimated is a closer approximation to the non-linear reality.

Figure A1.
Different mix of changes in teachers' wages and pupil per teacher ratio to increase countries' average scores 2 % and 5 %, respectively.

Source: Authors' own calculations.



Annex B

Other Factors Influencing Efficiency: Tutoring

One factor which is routinely ignored in an explanation of cross country education system differences is the extent to which the pupils of a country are tutored outside the regular state education system – either at Saturday school or private tutors at evenings or weekends. We asked respondents about this in our Global Teacher Status survey. The proportion varies considerably from 76 % in Greece to as low as 15 % in the Netherlands. (The full table of this proportion is included in Table D2.) We are naturally interested in understanding the extent to which extra tutoring can contribute to the performance of secondary education pupils.

Figure B1 below shows the correlation between these two variables for the 17 countries for which we have information on both variables. This figure suggests that extra tuition does not explain the variations in PISA scores. Despite this, there is at least some degree of correlation between pupils' performance and the efficiency of the educational systems. We proceed to establish the potential association between the Efficiency Index and the percentage of population receiving extra tutoring (Figure B2). Our results suggest that receiving extra tutoring does not contribute to higher rankings in terms of educational performance.

Figure B1. Correlation between PISA scores and Tutoring Received

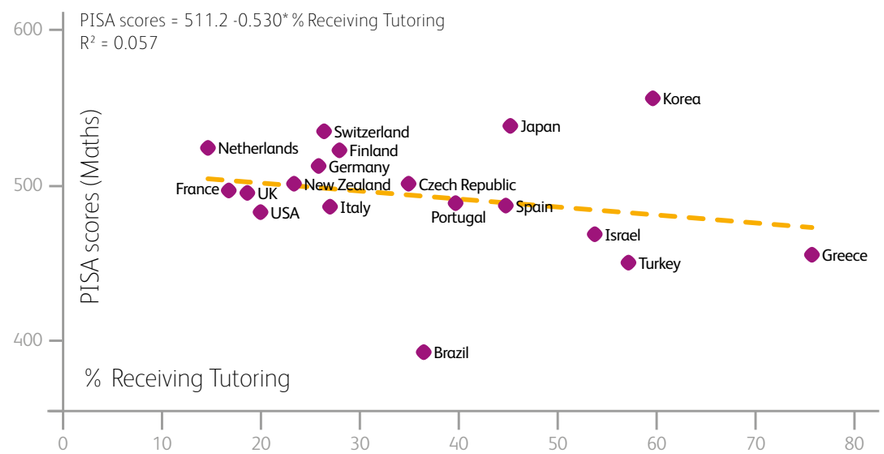
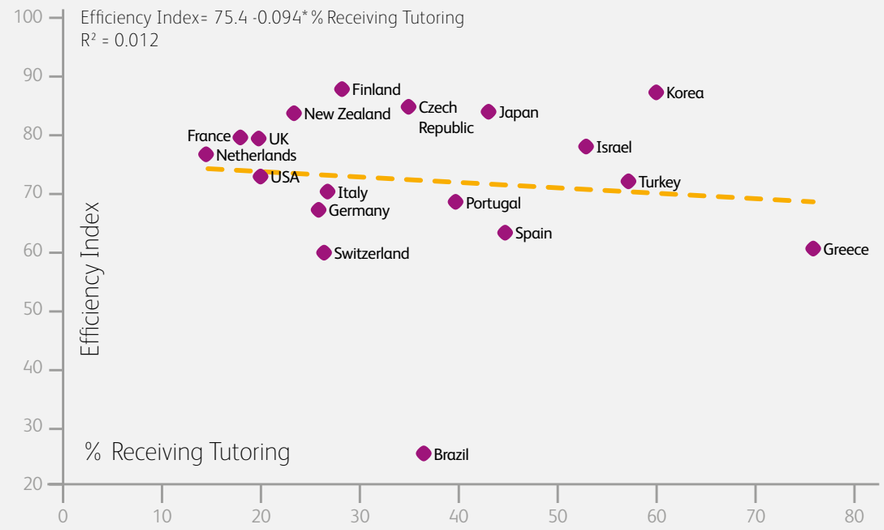


Figure B2. Correlation between Efficiency and Tutoring Received

Source: Table D2



Annex C
Time Invariance of Efficiency

Having developed the efficiency scores, it should be asked whether this score or its relative ranking across countries has changed materially over time. As an alternative, in Table C1 we take into account the variability over time of both inputs and output by estimating a panel model. As a result we can present a relative efficiency index for each country by year (the last column shows an average efficiency index across the time span of our estimates). The conclusion we draw from these scores is that there is stability of the relative index over the period. This can be taken as a demonstration of the consistency of the results to the extent that the classification of countries in terms of educational efficiency is very similar.

We have used upper secondary education data to estimate the efficiency index reported in Table C1. Nevertheless, when the estimates refer to lower secondary education the classification obtained is very similar.

We have selected some countries (highlighted in blue) whose efficiency index profile is plotted on Figure C1. This figure shows the distance in terms of efficiency for a set of developed countries.

Alternatively, Table C2 reports the results obtained by estimating a panel data model where we assume the time-invariant nature of the inefficiency term (Battese and Coelli, 1988). Again, the ranking of countries as measured by the efficiency index does not change substantially from what is shown above. Nevertheless, the relative distance among the countries widens.

One potential problem with this analysis is that the time-invariant nature of the inefficiency term can be called into question, particularly in the case of empirical applications based on long-panel data sets as at present analyses.

To overcome this, several alternative approaches have been suggested in the literature to date. In Figure C3 we plot the efficiency scores obtained from applying a "true random effects model", which, in the context of panel estimates, allows disentangling time-varying inefficiency from country-specific time-invariant unobserved heterogeneity. Again, the comparison of the rankings reported in Table C2 with those shown in previous tables provide further evidence on the consistency of our estimates.

Figure C1. Efficiency scores trend graphed.

Source: Authors' own calculations (see Table 2).

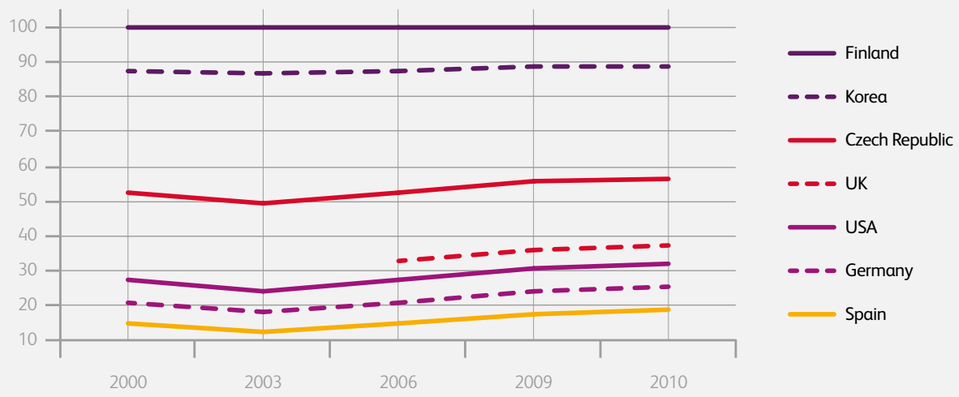


Table C1. Efficiency scores by country and year (countries ranked from lowest to highest score)

Base case: Year 2000.
Dependent variable: Average of math, science and reading scores by year (PISA).
Source: Authors' own calculations.

Ranking	Country	Efficiency 2000	Efficiency 2003	Efficiency 2006	Efficiency 2009	Efficiency 2010	Average Efficiency
30	Brazil	15.63	13.17				14.40
29	Spain	14.79	12.39	14.91	17.65	18.65	15.68
28	Greece	17.02	14.45	17.15			16.21
27	Switzerland		15.15	17.91	20.87		17.98
26	Indonesia		13.98		19.52	20.56	18.02
25	Portugal		14.78	17.51	20.44	21.50	18.56
24	Italy	20.30	17.51	20.43	23.53	24.64	21.28
23	Germany	20.92	18.10	21.06	24.18	25.30	21.91
22	Denmark	24.10	21.13				22.62
21	Norway	22.31	19.41	22.45	25.63	26.77	23.31
20	Belgium		20.52	23.62	26.84	27.99	24.74
19	Austria		21.63	24.77	28.04	29.20	25.91
18	Turkey		22.62	25.80	29.10	30.26	26.95
17	USA	27.12	24.04	27.27	30.61	31.78	28.16
16	Israel		24.99		31.61	32.79	29.80
15	Netherlands		27.22	30.55		35.12	30.96
14	France	30.37	27.19	30.52	33.91	35.10	31.42
13	Iceland	32.44	29.23	32.59	36.00	37.19	33.49
12	UK	32.65		32.80	36.22	37.41	34.77
11	Ireland	34.10	30.86	34.25	37.67	38.86	35.15
10	Australia		32.83	36.23	39.65	40.83	37.39
9	Chile		33.91	37.32	40.73	41.91	38.47
8	Slovenia			37.78	41.19	42.37	40.45
7	Sweden	42.08	38.84	42.23	45.59	46.74	43.09
6	New Zealand	43.34	40.12	43.50		47.98	43.73
5	Hungary	51.99	48.94	52.14	55.24	56.29	52.92
4	Czech Republic	52.42	49.38	52.56	55.65	56.70	53.34
3	Japan	53.73	50.72	53.87	56.91	57.94	54.63
2	Korea	87.57	86.50	87.62	88.66	89.00	87.87
1	Finland	100.00	100.00	100.00	100.00	100.00	100.00

Table C2.
Efficiency scores by country; panel time-invariant fixed-effects model

Note: Only countries with more than 1 time occasion are considered; thus Philippines, Thailand, Uruguay, Malaysia, Tunisia were removed from the estimates.
Source: Authors' own calculations.

Ranking	Country	Efficiency
30	Brazil	4.74
29	Indonesia	7.12
28	Greece	15.04
27	Turkey	18.66
26	Spain	20.03
25	Chile	20.43
24	Portugal	20.84
23	Italy	23.14
22	Switzerland	25.30
21	Israel	26.49
20	Denmark	26.95
19	Norway	28.05
18	Germany	28.06
17	Austria	29.61
16	USA	29.83
15	Belgium	32.66
14	France	34.87
13	Iceland	36.06
12	Ireland	39.19
11	Sweden	40.44
10	UK	41.10
9	Hungary	43.16
8	Netherlands	44.15
7	Czech Republic	45.82
6	Australia	46.35
5	Slovenia	49.14
4	New Zealand	54.52
3	Japan	64.07
2	Korea	86.38
1	Finland	100.00

Figure C2.
Efficiency Rank; panel time-invariant fixed-effects model

Source: Authors' own calculations (see Table C1).

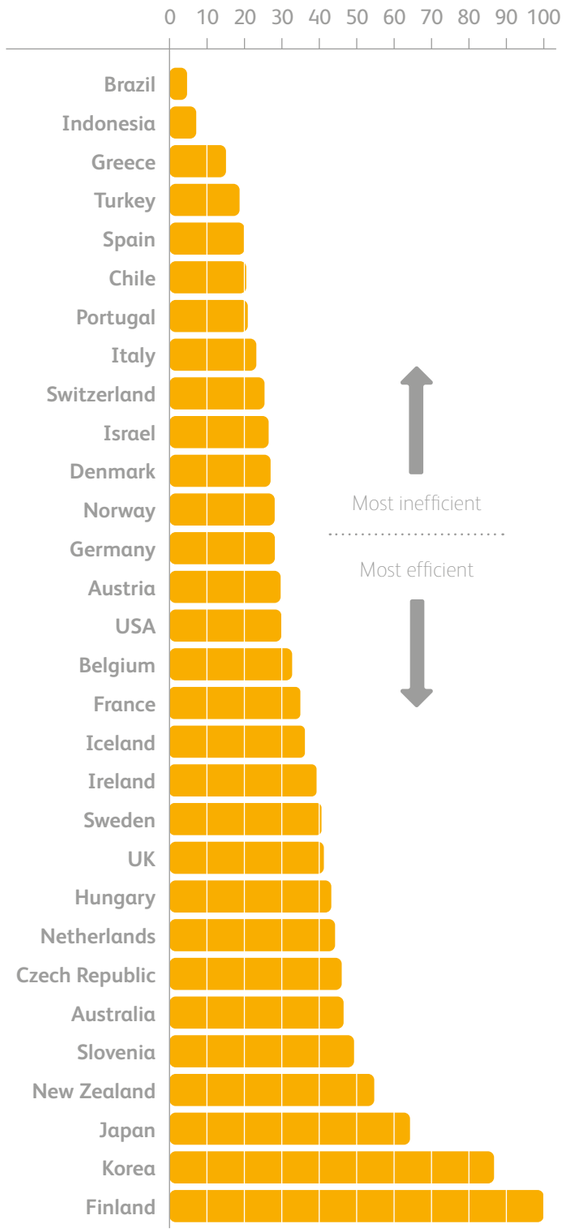
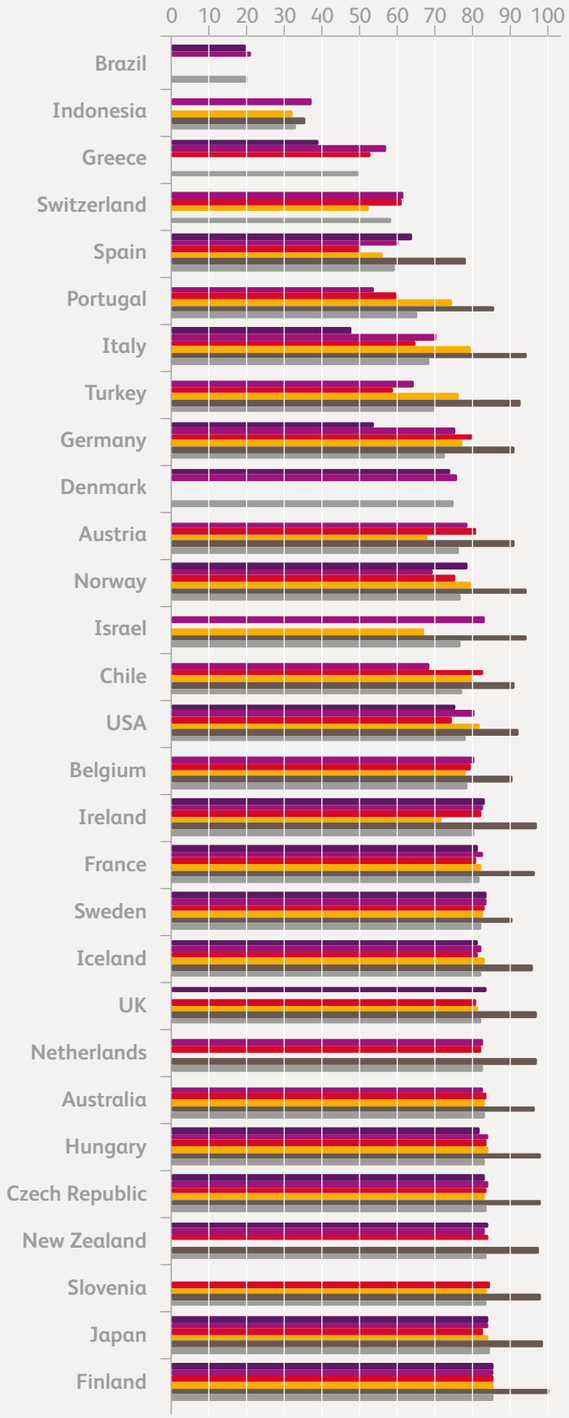


Figure C3.
Efficiency Ranking; Panel True random-effects model (exponential)

Source: Authors' own calculations.

The results we got using Data Envelopment Analyses instead of Stochastic Frontier Analyses confirm the previous results in terms of countries' efficiency ranking, thus we do not present them for the sake of brevity.



Annex D
Data Tables

Table D1.
Stochastic Frontier estimates -PISA scores- (cross section analysis: exponential distribution)

	Dependent variable: Mean standardised scores
Pupil/Teacher ratio	-0.035*** (0.013)
Teachers' salaries after 15 years in 1000$	0.031*** (0.004)
GDP growth (%)	0.004 (0.023)
2003	-0.157 (0.171)
2006	-0.045 (0.170)
2009	-0.260 (0.278)
2010	-0.070 (0.185)
Constant	0.030 (0.286)
Observations	129
Insig2v	0.459*** (0.058)
Insig2u	0.312*** (0.099)
λ	0.678*** (0.146)

Notes:
List of countries included in the estimates: See Table 1.
* significant at 10%;
** significant at 5%;
*** significant at 1%.

Base case: Year 2000.

Dependent variable: Mean of math, science and reading scores by year (PISA).

Source: Authors' own calculations.

Table D2.
Efficiency scores (%) by country (from lowest to highest)

Note 1: For those answering 'yes' to the question on whether they received extra tutoring we asked the type of tutoring they received. Consequently those columns report the % receiving each type of tutoring (the question allowed for multiresponse).

Note 2: Proportion of respondents answering that the type of school that did last attend was private or denominational or religious school (%).

Source: Authors' own calculations.

Efficiency Ranking	Country	Efficiency Index	Teacher's Status Index	% Receiving tutoring				Co-funding[2]	PISA scores 2012 (Maths)
				% Receiving any type of tutoring	One to[1] one	Saturday[1]	Other[1]		
30	Brazil	25.45	2.39	36.31	18.45	11.61	10.42	29.86	391
28	Switzerland	59.71	23.78	26.16	14.87	7.83	6.05	12.98	531
27	Greece	60.64	73.71	75.62	64.94	7.09	8.19	6.49	453
26	Spain	63.09	30.66	44.57	27.12	13.66	8.18	33.00	484
25	Germany	67.01	21.59	25.97	18.01	7.66	2.89	8.36	514
24	Portugal	68.29	26.04	39.38	29.61	10.97	2.89	14.06	487
23	Italy	69.81	12.97	26.77	14.03	6.77	7.56	10.35	485
21	Turkey	71.44	67.98	57.00	15.00	37.70	11.00	6.50	448
19	USA	72.66	38.45	19.80	11.34	6.37	5.07	16.62	481
14	Netherlands	76.8	40.28	14.58	5.26	4.37	6.25	22.22	523
13	Israel	77.84	2.00	52.70	29.00	20.00	13.10	19.90	466
12	France	78.69	32.30	17.26	7.44	6.35	4.07	24.01	495
11	UK	78.71	36.74	18.60	12.56	5.34	2.97	15.13	494
6	New Zealand	83.3	53.96	23.51	15.97	4.37	5.16	15.08	500
5	Japan	83.88	16.22	44.80	15.10	21.80	15.10	46.60	536
3	Czech Republic	84.38	12.11	34.77	14.39	6.39	16.38	7.39	499
2	Korea	86.66	62.00	59.80	28.12	33.37	12.18	57.03	554
1	Finland	87.81	28.90	27.89	5.78	22.01	3.39	7.97	519

Table D3. List of variables under scrutiny

Variables from OECD and IMF:

Starting teachers' wages	PISA Science-2009
Teachers' wages after 15 years of experience	PISA Maths-2012
Teachers' wages at the top	PISA Reading-2012
Net teaching time	PISA Science-2012
Expenditure	PIRLS Reading-2001
Student/Teacher	PIRLS Reading-2006
Growth population	PIRLS Reading-2011
Proportion of Women among staff	Math 8th grade TIMMS-1999
GDP per capita	Science 8th TIMMS -1999
GDP growth (%)	Math 8th grade TIMMS-2003
PISA Maths-2000	Science 8th TIMMS -2003
PISA Reading-2000	Math 4th grade TIMMS-2003
PISA Science-2000	Science 4th grade TIMMS-2003
PISA Maths-2003	Math 8th grade TIMMS-2007
PISA Reading-2003	Science 8th TIMMS -2007
PISA Science-2003	Math 4th grade TIMMS-2007
PISA Maths-2006	Science 4th grade TIMMS-2007
PISA Reading-2006	Math 8th grade TIMMS-2011
PISA Science-2006	Science 8th TIMMS -2011
PISA Maths-2009	Math 4th grade TIMMS-2011
PISA Reading-2009	Science 4th grade TIMMS-2011

New set of specific information on teachers and educational environment (from TIMSS):

Age	Regard for School Property
Gender	Pupils desire
FT Experience	Class size Maths & Science
PT Experience	Grade size Maths & Science
License	Maths: Sci teaching per week mins
Highest Level of Qualification	% reviewing homework
Main Area of Study	% listening
Specialization	% working problems
Teacher Interaction: Discussion	% working probs on own
Teacher Interaction: Materials	% listening re-teach
Teacher Interaction: Visits	% Tests quizzes
Teacher Interaction: Observation	Assign homework
Safe neighbourhood	How often homework
Feel Safe	Minutes homework
Security	Pupil ability differences
School Buildings	Pupil background
Overcrowded Classrooms	Special needs
Teacher workspace	Uninterested pupils
Materials	Disruptive pupils
Job Satisfaction	Professional development: content
Curricular goals	Pedagogy
Implementing curriculum	Curriculum
Expectations of pupils	Technology
Parental Support for achievement	Critical thinking
Parental Involvement	Assessment

Annex E
Econometric Methodology

We model the educational system as a company which attempts to obtain an output by the transformation of a set of inputs[14]. If we define y_i as the maximum potential performance which, on average, pupils can obtain for any given combination of inputs, in any country I, then equation **(1)** represents an educational frontier production model. This representation requires some assumption concerning the disturbance term. The two hypotheses which appear to satisfy the greatest level of acceptability lead us to differentiate between the deterministic frontier model and the stochastic frontier model. The stochastic frontier (SF) production function, as outlined by Aigner, Lovell and Schmidt (1977), Meeusen and Van den Broeck (1977) and Battese and Corra (1977) rely on the premise that the deviations from the production function are due to statistical noise. Such a stochastic factor cannot be attributed to the process of production, and hence should not be embedded in a single error term. Hence we require two stochastic terms as expressed in equation **(1)**[15],

$$y_i = \alpha + X'_i\beta + v_i - u_i \quad (1)$$

$$i = 1, \ldots, n$$

$$u_i \geq 0$$

where v_i is usually assumed to be a normally random variable (distributed independently of u_i) with mean zero and variance σ^2_v, and u_i a non-negative error typically assumed to be a half-normal distributed variable[13], with $\sigma^2_u > 0$. Furthermore, we assume both components of the compound disturbance to be independent and identically distributed (i.i.d.) across observations. The *independence assumption between u_i and v_i* is essential in order to obtain the derivation of the likelihood function. The marginalization of u_i gives closed-form expressions only for the Normal Half-Normal, Normal-Exponential and Normal-Truncated Normal models, but in other cases, like in the Normal-Gamma model, numerical or simulation-based techniques are required.

In this model $\lambda = \sigma^2_u / \sigma^2_v$, which is a measure of the degree of asymmetry of the $(v_i - u_i)$ disturbance term. The larger is λ the more pronounced will be the asymmetry, and correspondingly the OLS estimation is less justified. When we estimate equation **(1)** we obtain efficiency scores which can be used as a measured of the relative efficiency for the countries in our analysis, showing the 'best' combination of inputs to maximize average pupil performance.

In this research we now have panel data across countries, i, in years t. The richer information from panel data helps us to relax some of the assumptions in the previous model and to consider a *more realistic definition of the inefficiencies*. Pitt and Lee (1981) were the precursor in extending this model to panel data. They proposed the Maximum Likelihood estimation of the following Normal-Half Normal SF model:

$$y_{it} = \alpha + x'_i\beta + \varepsilon_{it} \; i = 2, \ldots, Nt = 2, \ldots, T_i \quad (2)$$

$$\varepsilon_{it} = v_i - u_i$$

$$v_{it} \sim N(0, \sigma^2_v)$$

$$u_{it} \sim N^+(0, \sigma^2_u) \qquad \textit{Half-Normal}$$

Battese and Coelli (1988) generalized this model to the Normal-Truncated Normal. Schmidt and Sickles (1984) highlighted that the estimation of a SF model with *time-invariant inefficiency* can also be performed by adapting conventional fixed-effects estimation techniques, by allowing inefficiency to be correlated with the frontier regressors and avoiding distributional assumptions about u_i. However, as we highlighted in the main body of the text, the *time-invariant nature of the inefficiency term has been put into question*, especially when empirical applications based on long panel data sets are present.

14 There are alternative econometric models to analyse cross country variation in countrywide educational performance –see for example Dolton and Marcenaro (2011).
15 As a result this model can be regarded as a generalisation of the standard regression model, the distinguishing feature of which is the presence of a one sided error (ui).

Cornwell et al. (1990) dealt with the problem by proposing the following SF model with individual-specific slope parameters:

$$y_{it} = \alpha + x'_{it}\beta \pm u_{it} i = 1, \ldots, Nt = 4, \ldots, T \quad (3)$$

$$u_{it} = w_i + w_{i1}t + w_{i2}\, t^2$$

where the model parameters are estimated extending the conventional fixed and random-effects panel data estimators. This quadratic specification allows a *unit-specific temporal pattern of inefficiency*, although a large number of parameters are required (Nx3).

Lee and Schmidt (1993) proposed an alternative specification in which u_{it} are specified as:

$$u_{it} = g(t).u_i \quad (4)$$

Where $g(t)$ is a set of time dummy variables. This specification is more parsimonious than Cornwell et al. (1990) and it does not impose any parametric specification, although it is less flexible, because it makes the temporal pattern of u_{it} to be the same for all productive units. Greene (2005a) defined a time-varying SF Normal-Half Normal model with unit-specific intercepts:

$$y_{it} = \alpha_i + x'_{it}\beta + \varepsilon_{it} \quad (5)$$

This specification allows distinguishing time-varying inefficiency from unit specific time invariant unobserved heterogeneity. Because of that, Greene named these models as "true" fixed (TFE) or random-effects (TRE), according to the assumptions on the unobserved unit-specific heterogeneity. Estimation of the true random-effects specification can be performed by using techniques based on simulation. The Maximum Likelihood (ML) estimation of the true fixed-effects variant requires the solution of two problems related to the estimation of nonlinear panel data models: The first issue is a computational problem due to the large dimension of the parameters space. Maximum Likelihood Dummy Variable (MLDV) approach is correct even in the presence of a large number of not favourable parameters α_i (N>1000). The second problem, incidental parameters problem, is an inferential issue due to the fact that the number of units is relatively large compared to the length of the panel. The $\alpha_i s$ are inconsistently estimated as $N \to \infty$ with fixed T, since only T_i observations are used to estimate each unit specific parameter (Neyman and Scott 1948; Lancaster 2002). Belotti and Ilardi (2012) showed that this inconsistency affects mostly the variance parameters, which are the main elements in the postestimation of inefficiencies. The MLDV approach seems to be correct only when the length of the panel is large enough $(T \geq 10)$.

Annex F
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